Chapter V

Aquatic Ecosystem Assessment

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Introduction

Cumulative effects of past and present human activities have degraded aquatic systems substantially. As a result, few high quality aquatic ecosystems remain in the United States. The Nationwide Rivers Inventory, completed in 1982 by the U.S. National Park Service, found that, of 3.25 million stream miles examined in the lower 48 states, less than 2 percent were considered of "high natural quality"(Benke, 1990). The phenomenon of diminishing aquatic system quality is not limited to riverine environments. Between the 1780's and the 1980's, the lower 48 states lost approximately 53 percent of all wetlands (Dahl 1990; Tiner 1991). Some states lost a much higher percentage than this; for example by the 1980's, only 9 percent of California's pre-European settlement wetlands remained. These studies only examined wetland loss and did not assess the health of those remaining. Thus, the actual area of high quality wetlands may likely be much lower than the total reported acres.

Common sources of aquatic system degradation include changes in water quality and quantity and habitat modification or destruction. These physical alterations often bring about changes in ecosystem organization. Key ecosystem components may be eliminated and processes leading to ecological recovery may be arrested (Steedman and Regier 1987). There may be reduced efficiency of nutrient cycling, changes in productivity, reduced species diversity, changes in the size distribution and life-history traits of the fauna, increased incidence of disease, and increased population fluctuations with increasing levels of stress (Woodwell 1970; Paloheimo and Regier 1982; Odum 1985; Rapport et al. 1985; Moyle and Leidy 1992).

The present condition of North America's native fish fauna is attributable, in part, to the degradation of aquatic ecosystems and habitat. Williams et al. (1989) listed 364 species and subspecies in need of special management consideration because of low or declining populations. This was an increase of 139 taxa since 1978. Many of these species were found in the western North America. Moyle and Williams (1990) found that 57 percent of the freshwater native fishes of California were extinct or in need of immediate attention. This decline in fish has also been accompanied by declines in other aquatic organism such as amphibians (Blaustein and Wake 1990).

Aquatic ecosystems in the range of the northern spotted owl exhibit signs of degradation and ecological stress. Recent studies reported the loss (Sedell and Froggatt 1984; Sedell and Everest 1991) or simplification of habitat (Bisson and Sedell 1984; Hicks et al. 1991a; Bisson et al. 1992) in streams. Approximately 55 percent of the 27,000 stream miles examined in Oregon are either severely or moderately impacted by nonpoint source pollution (Edwards et al. 1992). Over one third of Washington state's wetlands have been lost (Dahl 1990), and 90 percent of those remaining are considered degraded (Washington Department of Wildlife 1992). Concern about aquatic ecosystems is elevated with the identification of large numbers of native freshwater and anadromous fish species and stocks that require special management considerations due to low or declining numbers (Williams et al. 1989; Nehlsen et al. 1991).

Although several factors are responsible for declines of anadromous fish populations, habitat loss and modification are major determinants of their current status. Of the 314 at-risk anadromous salmonid stocks identified within the range of the northern spotted owl, only 55 occur solely on nonfederal land. Thus, federal agencies share in the responsibility for managing habitat for the other 259 at-risk stocks.

Over the last century, federal land within the range of the northern spotted owl has become increasingly important for ensuring the existence of high quality aquatic resources. Privately held forest lands have been developed into farms, urban areas, transportation corridors, and industrial forests. Conversion of native forest to tree farms and agriculture decreases the capacity of these lands to supply high quality aquatic resources. Thus, society's reliance on federal forest lands to sustain aquatic resources continues to grow. Congress recognized the role federal lands play through the Organic Act of 1897, establishing the National Forest Reserves for the "purpose of securing favorable conditions of water flows....for the use and necessities of the citizens of the United States."

An ecosystem approach is necessary to halt habitat degradation, maintain habitat and ecosystems that are currently in good condition, and to aid the recovery of habitat of at risk fish species and stocks. It should be noted that the forest ecosystem management options developed in this exercise can not resolve all issues contributing to the decline of anadromous salmonids, such as artificial propagation practices, and excess harvest in sport and commercial fisheries. They are centered on actions and programs that federal land-management agencies can implement to maintain and restore aquatic and riparian habitats on lands under their jurisdiction. This approach is both prudent and necessary given the current perilous state of many native salmon and trout stocks (Nehlsen et al. 1991; Higgins et al. 1992; U.S. Fish and Wildlife Service 1992), resident fish (Williams et al. 1989; U.S. Fish and Wildlife Service 1992), and other riparian-dependent organisms found on federal lands within the range of the northern spotted owl. In the following sections the scientific rationale for these conservation strategy scenarios is set forth and the specific elements are described.

This chapter describes and evaluates options for managing fish habitat and aquatic ecosystems on federal lands within the range of the northern spotted owl. We first describe the Regional setting encompassed by the range of the northern spotted owl. Second, the state of the aquatic biological resources within the northern spotted owl's range are outlined, including the status of aquatic organisms and the characteristics and present conditions of aquatic ecosystems. Third, the Aquatic Conservation Strategy that is aimed at maintaining and restoring the ecological health of aquatic ecosystems is proposed. This strategy includes three related scenarios that comprise the aquatic component of the 10 forest ecosystem management options developed by the Forest Ecosystem Management Assessment Team. We conclude by rating the sufficiency, quality, and distribution and abundance of habitat to allow fish species populations to stabilize over federal lands. Ratings for other late-successional and old growth associated species that may also be riparian dependents, such as vascular and nonvascular plants, amphibians, bats, and arthropods were provided in Chapter 4.

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Regional Context

Physiographic Setting

Stream and riparian habitat conditions vary greatly across the range of the northern spotted owl due to both natural and management-related factors. Precipitation ranges from several hundred inches per year in some areas near the coast to less than 20 inches east of the crest of the Cascade Range. Geologic and climatic history of uplift, volcanism, glaciation, and tectonism influence topographic relief, landforms and channel patterns, dominant types of erosion processes, and overall sediment production rates (Appendix). (Note: these provinces differ from those in Chapter 4 which are delineated primarily by vegetative type.) The type and structure of streamside vegetation reflects both climate and the disturbance regime of the area, determined by hydrology, geologic agents, and other processes such as forest fires. Many of these critical components of landscape form and function occur in distinctive combinations characteristic to each physiographic province in the region. Consequently, evaluation of stream and riparian conditions and programs for managing these ecosystems will be tailored ultimately to specific physiographic provinces and watersheds.

A critical aspect of the Pacific Northwest riverine and riparian environment is the widespread occurrence of steep, unstable hillslopes. Recent geologic uplift, weathered rocks and soil, and heavy rainfall all contribute to high landslide frequency and to high sediment loads in many of the region's rivers. Hillslope steepness is one of the simplest indicators of areas prone to debris slides and flows (rapid mass movements of soil and organic material down hillslopes and stream channels). The regional pattern of slope steepness, based on 90-meter resolution digital elevation model, displays extensive areas of slopes steeper than 50 percent (Figure 5-1), throughout the Forest Service and Bureau of Land Management lands of this region. This image (Figure 5-1) under-represents the extent of steep slopes in areas of short hillslope lengths, such as the southern part of the Oregon Coast Range. The steep slopes of the Siuslaw National Forest are better displayed with 30-meter digital elevation data (Figure 5-2).

Geographic patterns of slope instability can be revealed by combining rock stability characteristics with these slope steepness data. For example, such a map for the Siuslaw National Forest located in the Oregon coast range (Figure 5-3), displays extensive areas of high debris flow hazard which are greatest in the southern areas and generally decreasing towards the north. The Willamette National Forest, located in the Oregon western cascades, exhibits less extensive areas of high debris flow hazard, particularly in the high cascades (eastern half of the forest) underlain by young stable rocks (Figure 5-4). The western half of the Forest, where most general forestry operations have occurred, has some areas of high debris flow hazard in addition to high earthflow hazard.

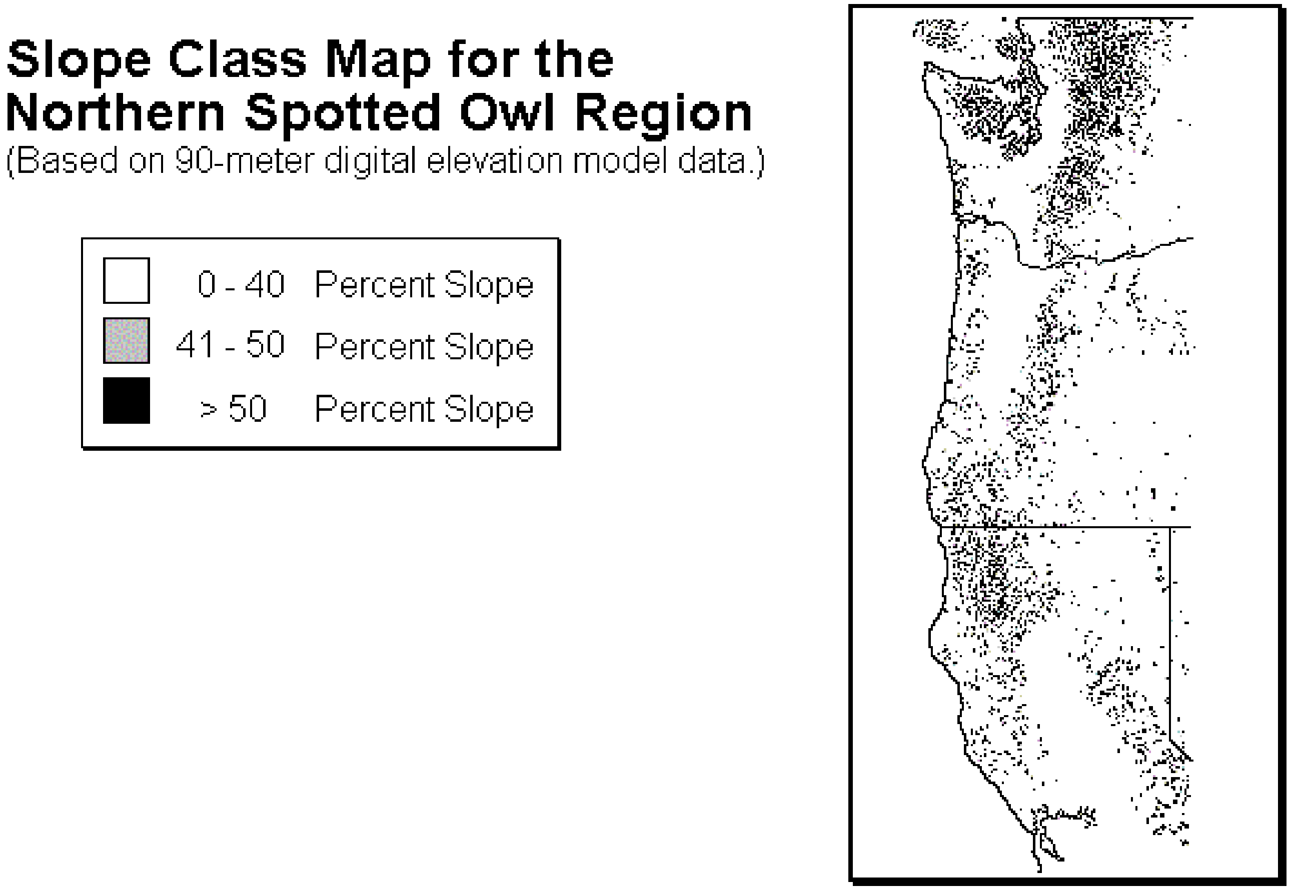

Figure 5-1. Slope class map for the northern spotted owl region, based on 90-meter digital elevation model data. Steepness in areas which have short slopes, such as in the Oregon Coast Range, is underrepresented due to the 90-meter resolution.

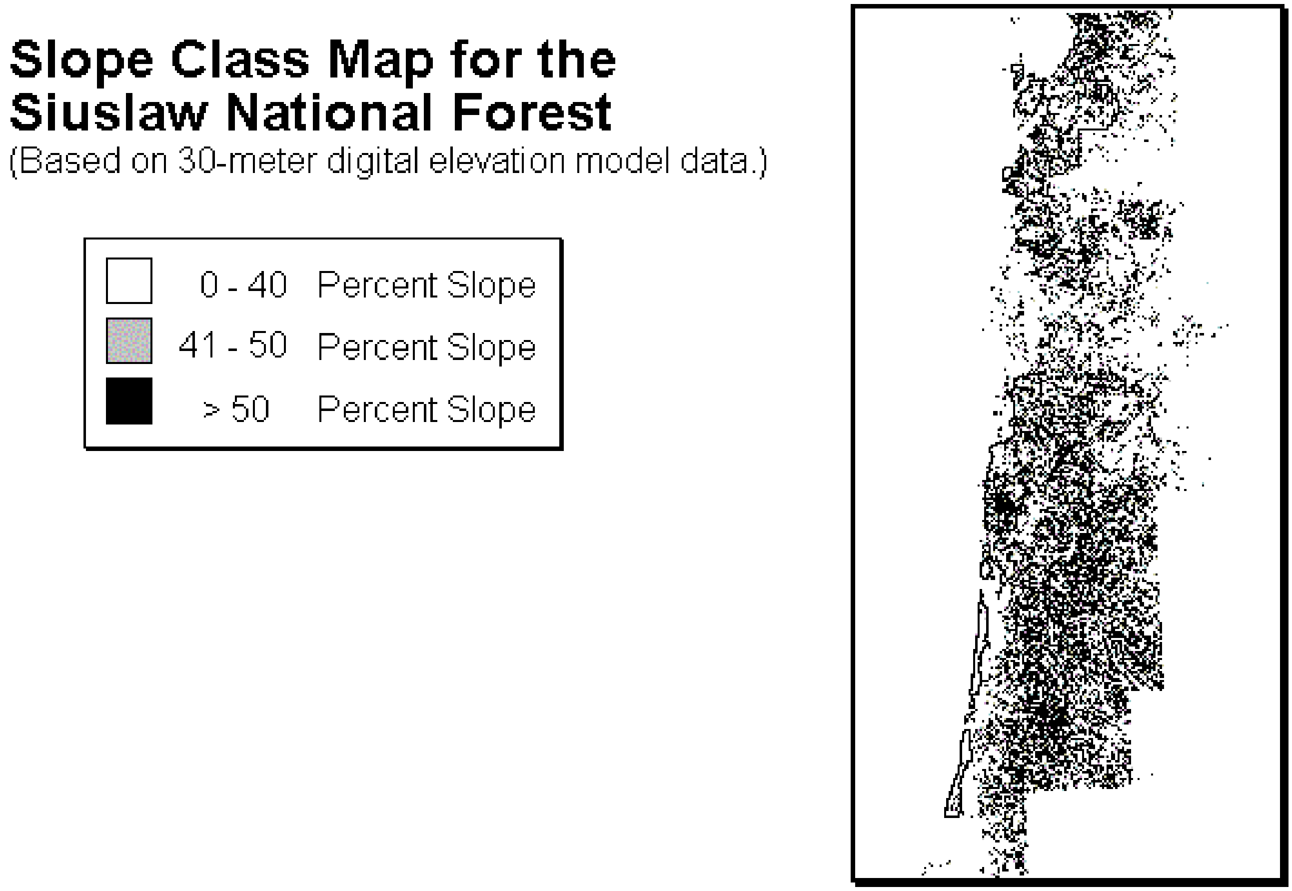

Figure 5-2. Slope class map for the Suislaw National Forest, based on 30-meter digital elevation model data.

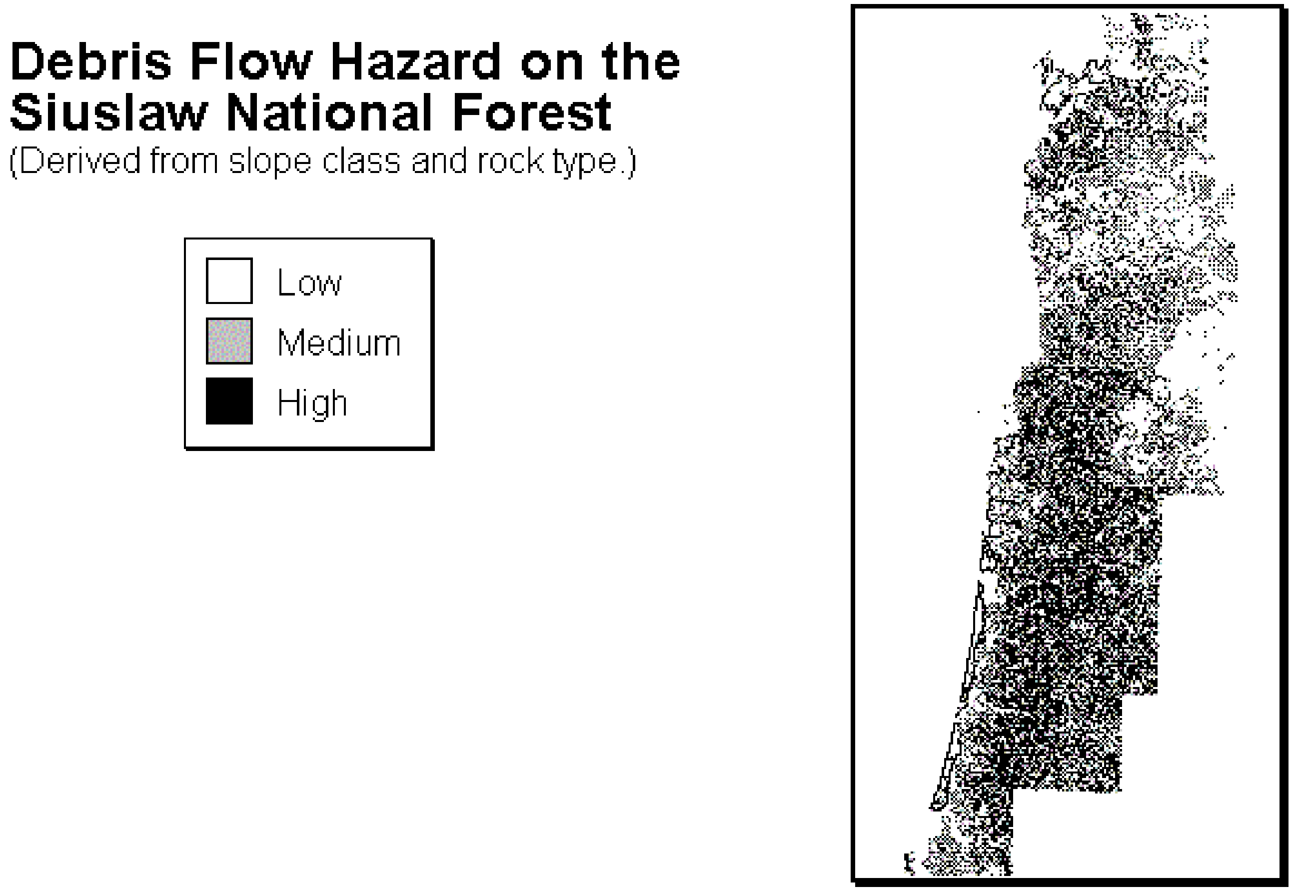

Figure 5-3. Debris flow hazard on the Suislaw National Forest derived from slope class and rock type.

Ocean Conditions and Near-shore Environments Affecting Anadromous Salmonids

Ocean conditions for anadromous salmonids in the range of the northern spotted owl are highly variable. The oceanic boundary between cool, nutrient-rich northern currents and warm, nutrient-poor southern currents occurs off the coast of northern California, Oregon, and Washington (Figure 5-5) (Fulton and LaBrasseur 1985). Favorable conditions exist when the boundary is more southerly. This situation occurred on an average of 1 in 4 years in the last 40 years (Bottom et al. 1986). During favorable ocean conditions, survival of at least some stocks is greater than during less favorable conditions (Nickelson 1986).

The coast in this region has a low shoreline/coastline ratio (Figure 5-6) (Bottom et al. 1986). As a consequence, there are few well-developed estuaries and other nearshore rearing areas. Many estuarine environments in the range of the northern spotted owl have been degraded or lost by dredging, diking, and agriculture and urban runoff. Estuaries are relatively protected sites of early growth in the marine environment and are important for future ocean survival of anadromous salmonids (Hager and Noble 1976; Bilton et al. 1982; Ward et al. 1989; Henderson and Cass 1991; Pearcy 1992). These areas are particularly important during periods of unfavorable ocean conditions. In much of the region of the northern spotted owl, salmonids moving to the ocean have limited near-shore areas in which to rear. In contrast, British Columbia and southeast Alaska have higher shoreline/coastline ratios and thus more and better near-shore and estuarine habitats.

The paucity of high quality near-shore habitats and variable ocean conditions makes freshwater habitat more crucial for the survival and persistence of anadromous salmonid stocks in the range of the northern spotted owl than it is for stocks in more northerly areas. Compared to areas with more stable ocean conditions and better developed near-shore habitats, anadromous salmonids in the region of the northern spotted owl are more dependent on freshwater environments to achieve larger sizes, which increase probability of marine survival.

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Status of Aquatic and Riparian Dependent Organisms

Anadromous Salmonids

Populations of anadromous salmonids become reproductively isolated from each other as they ascend their spawning streams. These locally adapted populations are referred to as stocks (Ricker 1972). More than 100 stocks are already extinct (Konkel and McIntyre 1987; Nehlsen et al. 1991) and hundreds of others are at risk of extinction throughout the Pacific Northwest. Because the Endangered Species Act includes provisions for listing "distinct population segments" of vertebrate species, some stocks of salmonids have been listed as endangered or threatened and other listings are probable (Williams et al. 1992). (See Appendix for common and scientific names of fish cited in this chapter.)

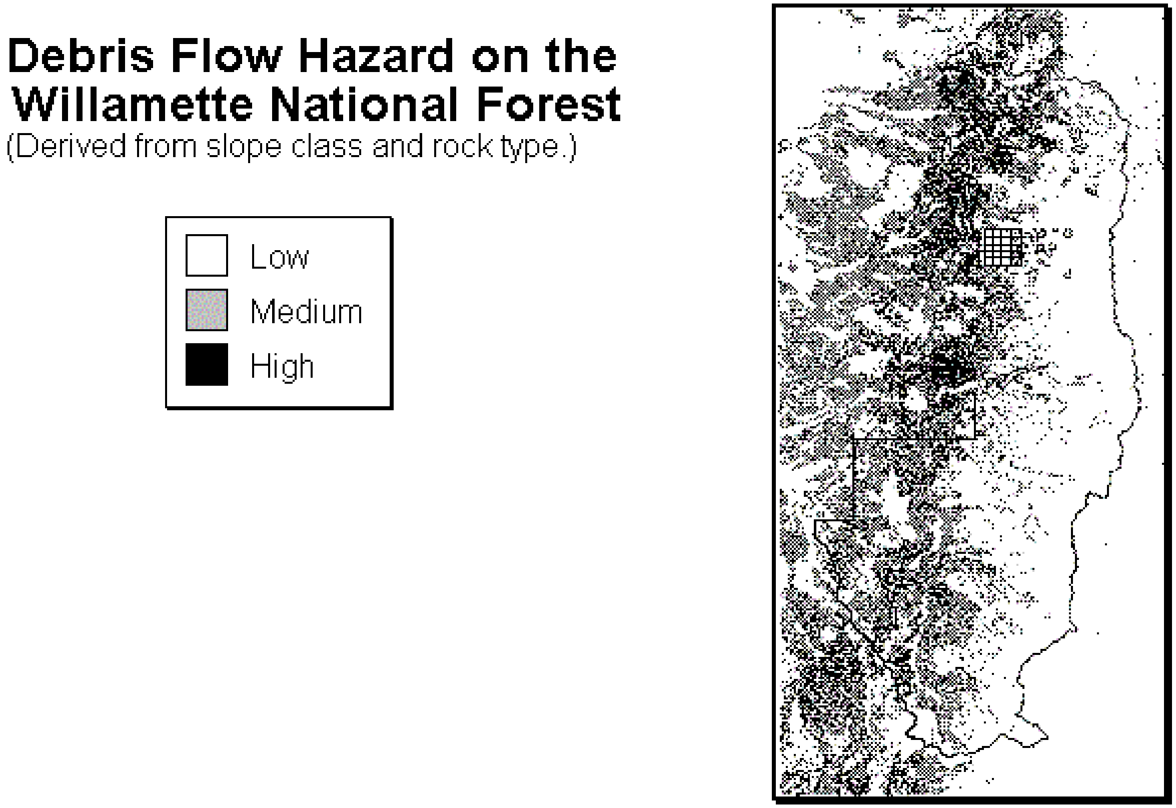

Figure 5-4. Debris flow hazard on the Willamette National Forest derived from slope class and rock type.

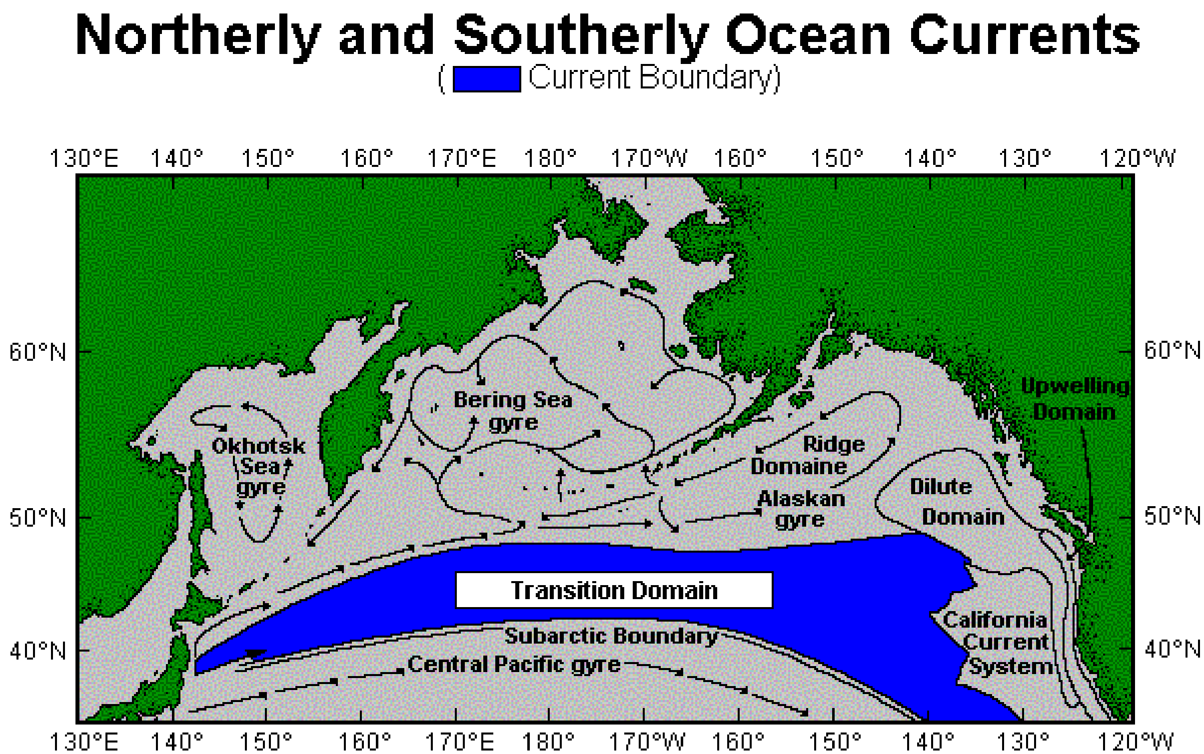

Figure 5-5. Location of the boundary between northerly and southerly ocean currents (blue area) (Fulton and LaBrasseur 1985).

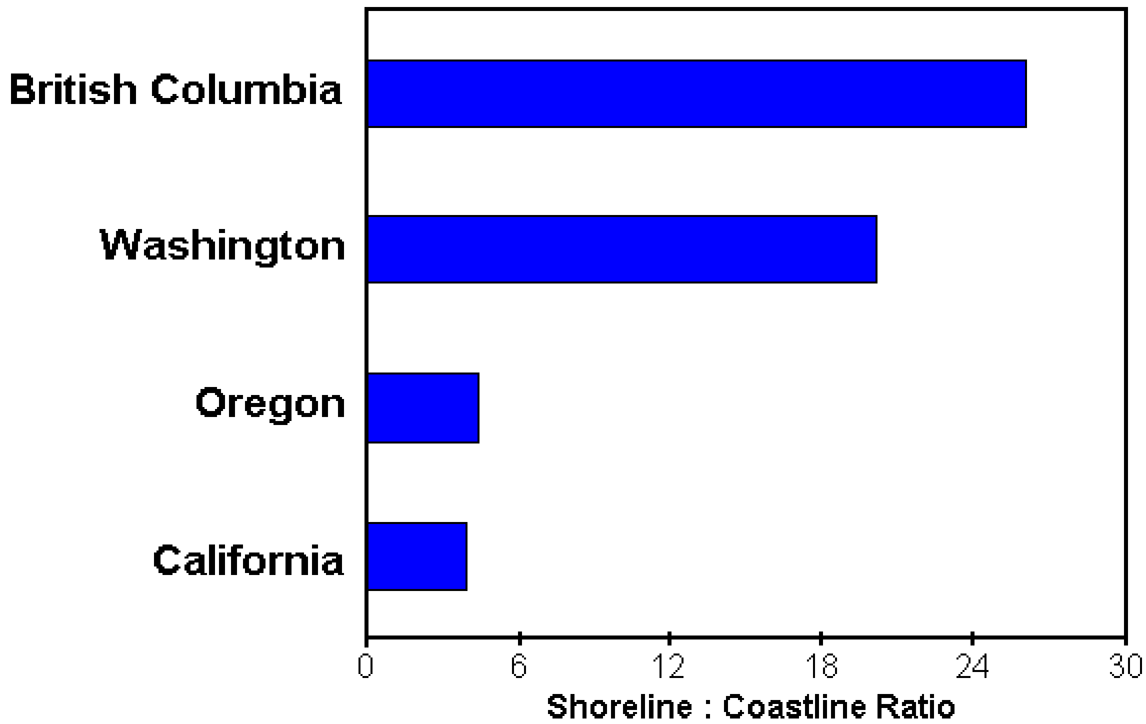

Figure 5-6. Shoreline:coastline ratio along the west coast of North America. Shoreline is a measure of the coastal perimeter, while coastline represents the straight latitudinal distance for each region. The number of bays and relative proportion of protected littoral habitat increase with an increasing shoreline:coastline ratio (Bottom et al. 1986).

The Endangered Species Committee of the American Fisheries Society recently identified 214 stocks of anadromous salmon and trout in California, Idaho, Oregon, and Washington in need of special management considerations because of low or declining numbers (Nehlsen et al. 1991). Of the 214, 101 were believed to be at a high risk of extinction, 58 at a moderate risk, and 54 were of special concern. Additional reports have been released on the status of West Coast anadromous salmonid stocks: Higgins et al. (1992) for northern California, Nickelson et al. (1992) for coastal Oregon streams, and Washington Department of Fisheries et al. (1993) for Washington. These recent reports provide more detailed stock assessments and in some cases, subdivide many of the stocks listed by Nehlsen et al. (1991).

Within the range of the northern spotted owl there are an estimated 314 anadromous salmonid stocks at risk (Appendix V-C - Not included in this hypertext), including all the stocks listed by Nehlsen et al. (1991) or Higgins et al. (1992) as having either a moderate or high risk of extinction or a similar rating by

Nickelson et al. (1992) or Washington Department of Fisheries et al. (1993). This includes 81 chinook, 98 coho, 6 sockeye, 28 chum, 6 pink, 89 steelhead trout, and 5 sea run cutthroat trout stocks (Appendix V-C - Not included in this hypertext). There are 259 of these stocks on federal lands within the range of the northern spotted owl.

However, not all of these anadromous salmonids stocks are likely to qualify as "species" pursuant to the Endangered Species Act. While the Act defines "species" to include "any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature," the National Marine Fisheries Service has further refined and interpreted the term "distinct population segment" as it applies to Pacific salmon. The National Marine Fisheries Service considers a stock to be "distinct" if it represents an evolutionarily significant unit of the biological species (Waples 1991). A stock, or group of stocks, must meet two criteria to be considered by the National Marine Fisheries Service to constitute an evolutionarily significant unit: (1) it must be substantially reproductively isolated from conspecific units, and (2) it must represent an important component in the evolutionarily legacy of the species. The second criterion could be confirmed, for example, if the stock contains unique genetic characters, a unique life history trait, or displays an unusual or distinctive adaptation to its environment.

To date, four populations of anadromous salmonids have been listed as threatened or endangered pursuant to the Endangered Species Act. One, the Sacramento winter chinook salmon is found within the range of the northern spotted owl. However, the amount of habitat for this stock on federal land is minimal. The other three are found outside the range of the spotted owl. Two stocks within the range of the northern spotted owl are presently being reviewed by the National Marine Fisheries Service to determine if they warrant listing pursuant to the Endangered Species Act. These are coastal steelhead trout, and the North and South Umpqua River sea run cutthroat trout.

Primary factors contributing to the decline of anadromous salmonid stocks include: (1) degradation and loss of freshwater and estuarine habitats; (2) timing and overexploitation in commercial and recreational fisheries; (3) migratory impediments such as dams; and (4) loss of genetic integrity due to the effects of hatchery practices and introduction of nonlocal stocks (Nehlsen et al. 1991). Often two or more of these factors operating in concert are responsible for a decline in population numbers.

Loss and degradation of freshwater habitats are the most frequent factors responsible for the decline of anadromous salmonid stocks (Nehlsen et al. 1991). This includes decreases in the quantity and quality of habitat and the fragmentation of habitat into isolated patches. These changes result from a suite of human activities that include agriculture, timber harvest and associated activities, road construction, livestock grazing, water withdrawal and diversion, and dams (Nehlsen et al. 1991). In the northern spotted owl region, the first four activities are primarily responsible for the loss or decrease in the quality of fish habitat. On federal lands, the most significant management activities affecting fish habitat are timber harvest and associated activities.

Resident Fish Species and Subspecies

Some resident fish populations have exhibited declines similar to those in anadromous salmonid stocks. We identified eight resident fish species within the range of the northern spotted owl that are at risk. Two, the Klamath shortnose sucker and the Lost River sucker, are listed under the Endangered Species Act. These species are found on the edge of the range of the northern spotted owl and their habitat is indirectly affected by timber harvest activities on federal lands. Five fishes are currently candidates for listing under the Endangered Species Act: the Oregon chub, the Olympic mudminnow, the Jenny Creek sucker, the McCloud River redband trout, and the bull trout. A status review by the U.S. Fish and Wildlife Service is currently underway for the bull trout. One other, the Salish sucker is identified as at risk by the American Fisheries Society (Williams et al. 1989) because of low or declining numbers.

Habitat loss and degradation are principal causal factors in declines of these fishes (Williams et al. 1989). In addition, introductions of nonnative fish and artificial propagation practices have impacted resident trout population. Like anadromous salmonid stocks, many of these fishes have been adversely affected by hatchery practices or overharvest.

Other Aquatic, Riparian and Wetland Organisms

The Forest Ecosystem Management Assessment Team evaluated 199 plant and animal species that use streams, wetlands, and riparian areas in late-successional forests (Table 5-1). Five species of riparian and aquatic vascular plants are of special concern under various state, federal, and agency listings (Chapter 4). These species are dependent on a predictable hydrologic regime, shade, and cool water for survival. Several species of lichens and bryophytes are also dependent on conditions in streams and riparian areas.

Amphibians require cool, moist conditions to maintain their respiratory functions. They are also sensitive to increased temperatures and sedimentation that may reduce reproductive and foraging success. Extirpation of populations in specific areas of the Pacific Northwest has occurred for several species and the ranges of several others has been drastically reduced (Corn and Bury 1989; Blaustein and Wake 1990). Forest dwelling species have declined the most. As a result, several species of amphibians are currently candidates for listing under the Endangered Species Act (U.S. Fish and Wildlife Service 1992).

Species Associated with Late-Successional and Old-Growth Forests

Vasular Plants	29
Lichens	
Aquatic	3
Riparian	9
Bryophytes	
Aquatic	3
Splash Zone	5
Floodplain	13
Mollusks	
Freshwater Snails	54
Freshwater Clams	3
Ampibians	
Salamanders	12
Frongs	1
Birds	38
Mammals	18
Bats	11
Total	**199**

Table 5-1. Species associated with late-successional and old-growth forests utilizing streams, wetlands, and riparian areas. Vascular plants, lichens, mosses, and mollusks are exclusively associated with aquatic, wetland, or riparian habitats. Vertebrate species significantly utilize riparian areas for foraging, roosting, and travel if old forest conditions are present. (Derived from Chapter 4.)

Many freshwater mollusk species have restricted distributions, often being found in single stream systems, springs and seeps (Chapter 4). They are sensitive to changes in flow conditions and increased levels of sedimentation.

Many species of aquatic invertebrates are proposed for listing under state or federal endangered species laws. However, in general not enough information is known about them to adequately address their current status or whether additional species should be examined (Chapter 4).

Characteristics of Aquatic Ecosystems and Present Habitat Condition

Understanding current conditions and future options for aquatic ecosystems in the Pacific Northwest requires an appreciation of those physical and biological processes and elements that create and maintain habitat. These factors derive from upland terrestrial and aquatic environments as well as the riparian area, a zone of transition between these areas in which vegetation and microclimate are strongly influenced by the aquatic system (Gregory and Ashkenas 1990; Gregory et al. 1991). Here we consider the critical components of aquatic ecosystems and their current conditions in the range of the northern spotted owl.

Key physical components of a fully functioning aquatic ecosystem include complex habitats consisting of floodplains, banks, channel structure (i.e. pools and riffles), water column and sub-surface waters. These are created and maintained by rocks, sediment, large wood, and favorable conditions of water quantity and quality. Upslope and riparian areas influence aquatic systems by supplying sediment, large wood and water. Disturbance processes such as landslides and floods are important delivery mechanisms. Over time scales of 1-100 years, streams are clearly disturbance dependent systems (Pringle et al. 1988). To maintain community viability throughout a large drainage basin, it is necessary to maintain features of the natural disturbance regime (i.e., frequency duration, and magnitude) in different portions of a basin. Aquatic ecosystems consist of a diversity of species, populations and communities that may be uniquely adapted to these specific structures and processes.

Spatial and temporal connectivity within and between watersheds is necessary for maintaining aquatic and riparian ecosystem functions (Naiman et al. 1992). A large river basin can be visualized as a mosaic of a terrestrial "patches" (Pickett and White 1985) or smaller watersheds linked by stream, riparian, and sub-surface networks (Stanford and Ward, 1992). Lateral, vertical, and drainage network linkages are critical to aquatic system function. Important connections within basins include linkages among headwater tributaries and downstream channels as paths for water, sediment, and disturbances; and linkages among floodplains, surface water, and ground water systems (hyporheic zones) as exchange areas for water, sediment and nutrients. Unobstructed physical and chemical paths to areas critical for fulfilling life history requirements of aquatic and riparian-dependent species must also be maintained. Connections among basins must allow for movement between refugia.

The following discussion of aquatic ecosystems focuses on third to fifth order streams (Strahler 1957); these streams are generally 10-60 feet wide and are representative of most aquatic systems on federal lands within the range of the northern spotted owl. Streams of this size support mixed species assemblages of juvenile anadromous salmonids and resident fish. Not all of the desired features are expected to occur in a specific reach of stream, but they generally occur throughout a productive watershed.

Instream Components

Large Wood

Large quantities of downed trees are a functionally important component of many streams (Swanson et al. 1976; Sedell and Luchessa, 1982; Sedell and Froggat, 1984; Harmon et al. 1986; Bisson et al. 1987; Maser et al. 1988; Naiman et al. 1992). Large woody debris influences channel morphology by affecting longitudinal profile, pool formation, channel pattern and position, and channel geometry (Bisson et al. 1987). Downstream transport rates of sediment and organic matter are controlled in part by storage of this material behind large wood (Betscha 1979). Large wood affects the formation and distribution of habitat units, provides cover and complexity, and acts as a substrate for biological activity (Swanson et al. 1982b; Bisson et al. 1987). Wood enters streams inhabited by fish either directly from the adjacent riparian zone from tributaries that may not be inhabited by fish, or hillslopes (Naiman et al. 1992).

Large wood in streams has been reduced due to a variety of past and present timber harvesting practices and associated activities. Many riparian management areas on federal lands are inadequate as long term sources of wood. Widths of intact riparian areas have been reduced by timber harvest activities. Furthermore, in some areas where riparian buffers have been established, partial harvest and salvage logging within them have reduced their ability to contribute large wood to streams (Bryant 1980; Bisson et al. 1987). Also, absence of protection for riparian areas for nonfish-bearing streams has reduced the amount of wood which these streams could deliver to fish-bearing streams (Naiman et al. 1992). Debris flows and dam break floods resulting from natural processes or timber harvest activities may remove large wood from channels and riparian vegetation from streambanks on one portion of a drainage system and deposit this material downstream (Benda and Zhang, 1990; Swanston 1991).

Other human activities have also resulted in the loss of wood in streams. Mandated cleanup activities removed wood from streams throughout the region of the northern spotted owl from the 1950's through 1970's (Narver 1971; Bisson and Sedell 1984). Earlier activities such as splash damming, which stored water to flood streams and transport logs, also removed large amounts of wood from streams (Sedell and Luchessa 1982; Sedell et al. 1991).

Water Quality

High water quality is essential for survival, growth, reproduction, and migration of individuals composing aquatic and riparian communities. Elements of water quality that are important for aquatic organisms include water temperatures within a range that corresponds with migration and emergence needs of fish and other aquatic organisms (Sweeney and Vannote 1978; Quinn and Tallman 1987). Desired conditions include an abundance of cool (generally less than 68ºF), well oxygenated water that is present at all times of the year, free of excessive amounts of suspended sediments (Sullivan et al. 1987) and other pollutants that could limit primary production and benthic invertebrate abundance (Cordone and Kelley 1961; Lloyd et al. 1987).

The U.S. Environmental Protection Agency reporting the results of state 305(b) and 319 assessments found many streams on lands managed by the U.S. Forest Service and Bureau of Land Management in the range of the northern spotted owl to be either moderately or severely impacted by increases in water temperature and sedimentation (Edwards et al. 1992). On federal lands in Oregon, 55 percent (20,400 miles) of the streams are moderately or severely impaired (Figure 5-7). On Bureau of Land Management lands, 7,300 miles of streams, and 4,900 miles of streams on Forest Service lands have water temperature problems. An additional, 8,000-11,000 miles have problems with turbidity, erosion, and bank instability. See Appendix V-D (Not included in this hypertext) for a more detailed discussion.

The Regional Ecosystem Assessment Project of Region 6 of the Forest Service attempted, as a first approximation, to compare current aquatic ecosystem conditions with the range of natural conditions to discover "where forests are in or out of balance." Comparable data were provided by National Forests in northern California and Bureau of Land Management. Although the range of natural conditions was estimated by compiling data from existing sources and professional judgment, results indicate a simplification of habitat and a reduction in aquatic system quality in the majority of river basins.

The Regional Ecosystem Assessment Project used maximum daily stream temperature as an indicator of aquatic ecosystem conditions. The range of natural conditions was estimated for a river basin using knowledge of temperatures in wilderness or other unmanaged areas. In the absence of existing stream temperature data, current conditions were estimated based on ground water or air temperature data. For a majority of rivers, current maximum stream temperatures exceeded the warmest estimated naturally occurring temperatures or were in the upper portion of the range of natural conditions (Figure 5-8).

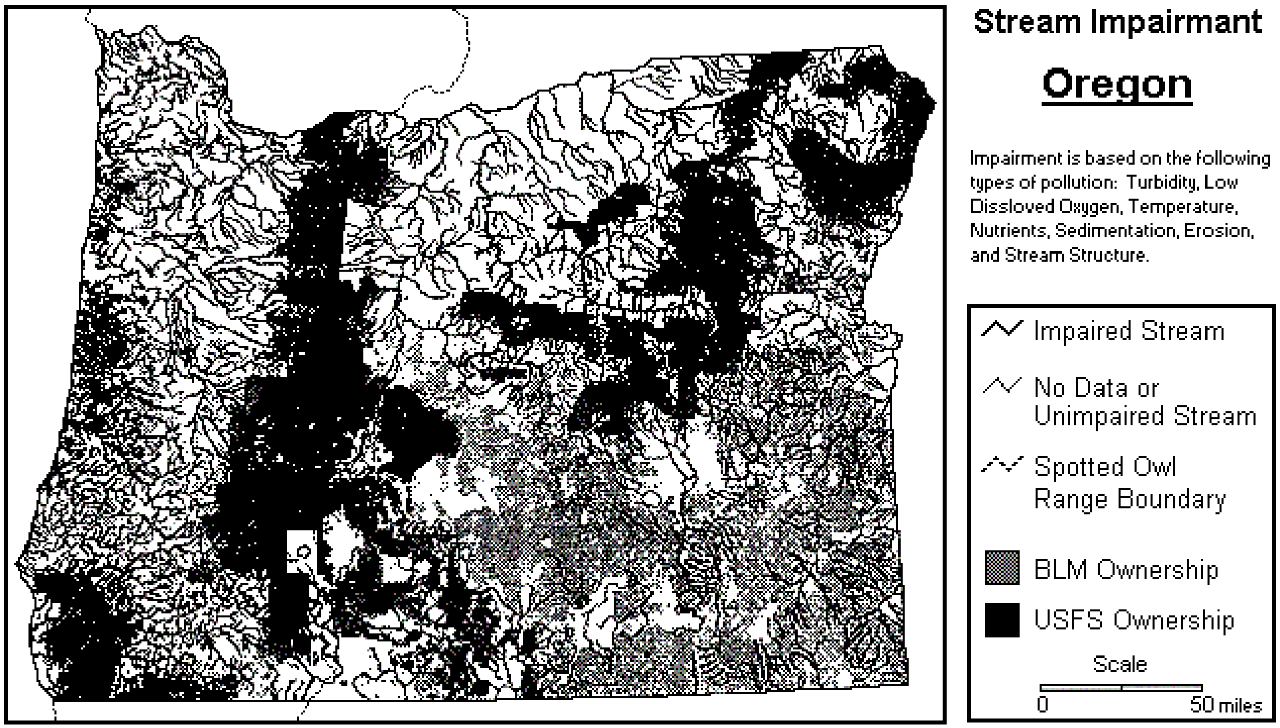

Figure 5-7. Stream Impairment for the state of Oregon.

Increased water temperature can often be traced to removal of shade producing riparian vegetation along fish bearing streams and along smaller tributary streams that supply cold water to fish-bearing streams (Beschta et al. 1987; Bisson et al. 1987). Removal of streambank vegetation has resulted largely from timber harvest in riparian areas.

Changes in the water temperature regime can affect the survival and production of anadromous salmonids, even when temperatures are below levels considered to be lethal. For example, Reeves et al. (1987) found that interspecific competition between redside shiners and juvenile steelhead trout was influenced by water temperature; trout dominated at lower temperatures (less than 68ºF) and shiners at higher temperatures (greater than 68ºF). In Carnation Creek, British Columbia, water temperatures during both summer and winter changed because of timber harvest activities. The consequence of this was accelerated growth and earlier migration of juvenile coho salmon (Holtby 1988). However, Holtby speculated that survival of coho salmon to adults would decrease because of the earlier time of ocean entry. Berman and Quinn (1991) found that fecundity and viability of eggs of adult spring chinook salmon were affected by elevated water temperatures.

Accelerated rates of erosion and sediment yield are a consequence of most forest management activities. Road networks in many upland areas of the Pacific Northwest are the most important source of management-accelerated delivery of sediment to anadromous fish habitats (Ice 1985; Swanson et al. 1985). The sediment contribution to streams from roads is often much greater than that from all other land management activities combined, including log skidding and yarding (Gibbons and Salo 1973). Road-related landsliding, surface erosion and stream channel diversions frequently deliver large quantities of sediment to steams, both chronically and catastrophically during large storms (Swanson and Dyrness 1975; Swanston and Swanson 1976; Beschta 1978; Gardner 1979; Reid and Dunne 1984). Roads may have unavoidable effects on streams, no matter how well they are located, designed or maintained. Many older roads with poor locations and inadequate drainage control and maintenance pose high risks of erosion and sedimentation of stream habitats.

Federal lands within the range of the northern spotted owl contain approximately 110,000 miles of roads (Table 5-2). A substantial proportion of this network constitutes current and potential sources of damage to riparian and aquatic habitats, mostly through sedimentation. Roads in uplands cross streams frequently. There are an estimated 250,000 stream crossings (culverts) in the road network. The majority of these stream crossings cannot tolerate more than a 25-year flow event without failure. The chance of a 25-year flow event is about 34 percent in 10 years, and 70 percent in 30 years (Figure 5-9). When stream crossings fail, a local dam-break flood usually occurs, resulting in severe impacts to water quality and habitat.

Roads modify natural hillslope drainage networks and accelerate erosion processes. These changes can alter physical processes in streams, leading to changes in streamflow regimes, sediment transport and storage, channel bank and bed configurations, substrate composition, and stability of slopes adjacent to streams. These changes can have significant biological consequences that affect virtually all components of stream ecosystems (Furniss et al. 1991).

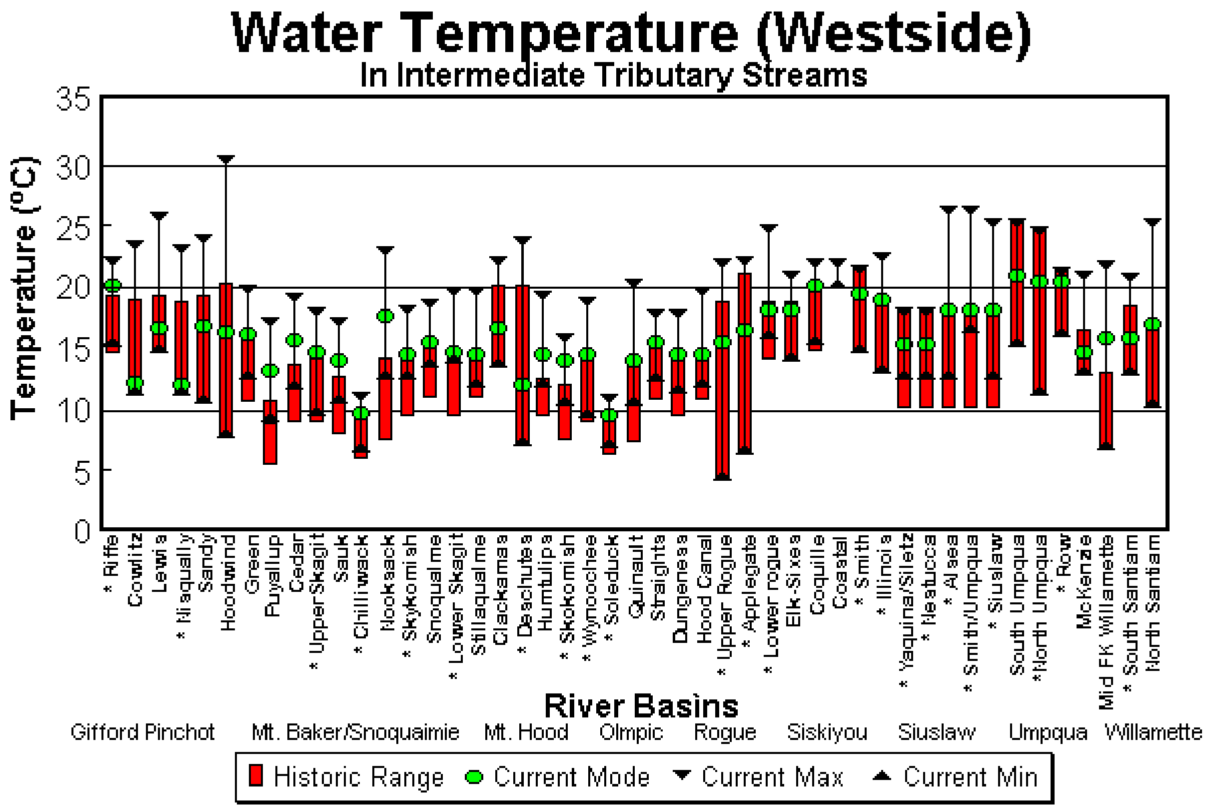

Figure 5-8. Historic range, current range, and current mode of water temperature for streams west of the Cascade Mountains in Washington and Oregon. Basins that had limited data are shown by (*). (USDA Forest Service 1993).

Table 5-2. Summary of Road Development on Public Lands in the Range of the Northern Spotted Owl

National Forest or BLM District	Total Road Miles	ML 1[1] Miles	ML 1 %	ML 2[2] Miles	ML 2 %	"Public"[3] Road Miles	Public Road %	Native Surface Miles	Native Surface %	Gross area minus wilderness (sq.mi.)	Net roaded area[4] (sq.mi.)	% of non-wilderness in roadless	Road Density (mi./sq. mi.)
Deschutes NF	8,722	469	5	7,535	86	718	8	7,009	80	2,179	2,009	8	4.34
Mt. Hood NF	3,818	443	12	2,236	59	1,139	30	845	22	1,428	1,211	15	3.15
Rogue River NF	2,782	90	3	1,830	66	862	31	1,055	38	837	711	15	3.92
Siskiyou NF	2,949	300	10	2,092	71	557	19	689	23	1,343	899	33	3.28
Siuslaw NF	2,540	220	9	1,625	64	695	27	115	5	910	868	5	2.92
Umpqua NF	4,880	1,276	26	2,447	50	1,157	24	1,132	23	1,498	1,325	12	3.68
Willamette NF	6,424	700	11	3,757	58	1,967		380	6	2,023	1,768	13	3.63
Winema NF	6,221	1,848	30	3,111	50	1,262	20	5,374	86	1,488	1,451	2	4.29
Coos Bay BLM	1,924										511		3.76
Medford BLM	5,628										1,436		3.92
Eugene BLM	1,935										492		3.94
Roseburg BLM	2,924	Road maintenance level and surfacing data not available for BLM lands.									655		4.46
Salem BLM	2,636										622		4.23
Arcata BLM	135										277		0.49
Redding BLM	350										387		0.90
Gifford-Pinchot NF	4,341	569	13	2,777	64	995	23	719	17	1,861	1,525	18	2.85
Mt. Baker-Snoqualmie	2,988	615	21	968	32	1,405	47	94	3	1,565	934	40	3.20
Okanogan NF	2,665	477	18	1,158	43	1,030	39	1,615	61	1,688	1,226	27	2.17
Olympic NF	2,463	556	23	1,207	49	701	28	1,446	59	872	738	15	3.34
Wenatchee NF	5,069	840	17	3,214	63	1,015	20	3,362	66	2,067	1,198	42	4.23
Klamath NF	4,656	895	19	2,478	53	1,284	28	3,295	71	1,477	1,100	26	4.23
Shatsta-Trinity NF	6,528	981	15	3,914	60	1,633	25	4,939	76	2,690	2,255	16	2.89
Mendocino NF	2,486	619	25	1,402	56	465	19	2,422	97	1,477	1,255	16	1.10
Six Rivers NF	2,489	648	25	1,192	48	649	26		0	1,304	1,085	17	2.29
Totals	**87,554**	**11,547**	**13**	**42,941**	**49**	**17,534**	**20**	**34,491**	**39**	**26,707**	**25,940**		**3.38**
adjusted by 1.25[5]	109,443												4.22

[1] ML 1 - Maintenance Level 1 are roads that are closed but still considered part of the transportation system.

[2] ML 2 - Maintenance Level 1 are roads suitable for high-clearance vehicles only.

[3] "Public" - refers to roads that are designed and maintained for normal-clearance (FS Maintenance Levels 3, 4, &5).

[4] Derived by subtracting Inventoried Roadless Area acreage from gross NF acreage without Wilderness.

[5] Estimated adjustment for non-system roads.

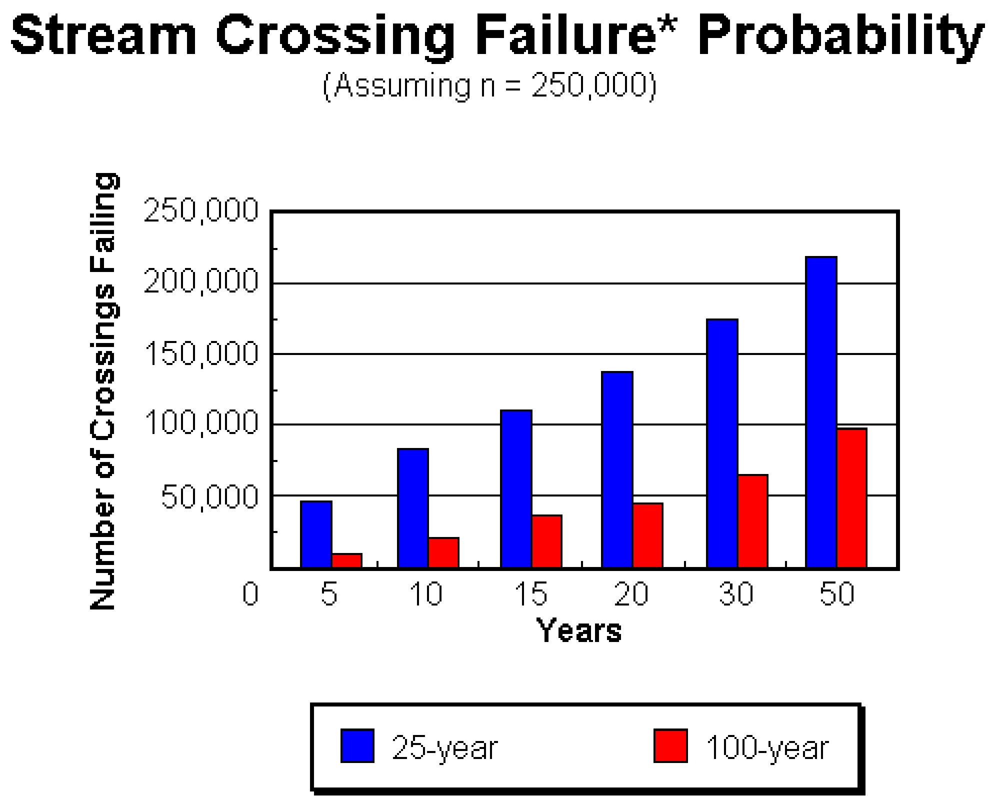

Figure 5-9. Theoretical probability of stream crossing failure. Values are based on: $J = 1 - (1 - 1/T)^N$, where N = number of years considered, T = flood recurrence interval, J = chance of failure (Schmidt 1981). Probabilities for an individual crossing sized for 25- and 100-year flows were multiplied by the total estimated number of crossings on public lands within the range of the northern spotted owl (~250,000). *Analysis assumes random spatial distribution of storms, and that exceedance of design flows constitutes crossing failure. The actual consequences of design flow exceedance would vary widely.

Increased levels of sedimentation often have adverse effects on fish habitats and riparian ecosystems. Fine sediment deposited in spawning gravels can reduce survival of eggs and developing alevins (Everest et al. 1987; Hicks et al. 1991a). Primary production, benthic invertebrate abundance, and thus, food availability for fish may be reduced as sediment levels increase (Cordone and Kelley 1961; Lloyd et al. 1987). Social (Berg and Northcote 1985) and feeding behavior (Noggle 1978; Sigler et al. 1984) can be disrupted by increased levels of suspended sediment. Pools, an important habitat type, may be lost due to increased levels of sediment (Kelsey et al. 1981; Megahan 1982).

Water Quantity

Aquatic organisms require adequate flows be maintained at critical times to satisfy requirements of various life stages. For example, fish are adapted to natural variations in flow regimes but may be adversely affected by disturbances that alter natural flow cycles (Statzner et al. 1988). Timing, magnitude, duration, and spatial distribution of peak and low flows must be sufficient to create and sustain riparian and aquatic system habitat and to retain patterns of sediment, nutrient, and wood routing. The timing, variability, and duration of floodplain inundation and water table elevation in meadows, floodplains and wetlands affect maintenance of main channel connectivity within these areas.

Timber harvest and associated activities can alter the amount and timing of streamflow by changing onsite hydrologic processes (Keppeler and Ziemer 1990; Wright et al. 1990). These activities, which include harvest, thinning, yarding, road building, and slash disposal can produce changes that are either short-lived or long-lived depending on which hydrologic processes they alter and the intensity of the alteration (Harr 1983). Thus, changes in the hydrologic system caused by road building are most pronounced where road densities are the greatest (Harr et al. 1979; Wright et al. 1990; Ziemer 1981). Similarly, the effects of clearcut logging on hydrologic processes are greater than those resulting from thinning (Harr 1983; Harr et al. 1979).

Changes in hydrologic processes can be grouped into two classes according to causal mechanisms. One class consists of changes resulting from removing forest vegetation through harvest. These changes, which can be very large close to the harvest areas immediately following harvest, gradually diminish over time as vegetation regrowth occurs (Harr 1983; Harr et al. 1979; Harris 1977; Hicks et al. 1991b). Processes that depend on the amount and size of forest vegetation include rain or snow interception, fog drip (Azevedo and Morgan 1974; Byers 1953; Harr 1982; Ingwerson 1985; Isaac 1946), transpiration (Harr 1983; Harr et al. 1979, 1982), and snow accumulation and melt (Berris and Harr 1987; Coffin and Harr 1992; Harr 1981; Troendle 1983; Swanson and Golding 1982). These processes, most of which are at least partially energy-dependent, all increase the amount or timing of water arriving at the soil surface and the resultant amount of water flowing from a logged watershed. The longevity of changes in these processes brought about by timber harvest generally is on the order of three to four decades and is related to vegetation characteristics such as tree height, leaf area, canopy density, and canopy closure (Coffin and Harr 1992; Harr and Coffin 1992; Troendle 1983; Hicks et al. 1991b).

A second class of changes in hydrologic processes consists of those that control infiltration and the flow of surface and subsurface water. This class is dominated by the effects of forest roads. The relatively impermeable surfaces of roads cause surface runoff that bypasses longer, slower subsurface flow routes (Harr et al. 1975, 1979; Ziemer 1981). Where roads are insloped to a ditch, the ditch extends the drainage network, collects surface water from the road surface and subsurface water intercepted by roadcuts, and transports this water quickly to streams (Figure 5-10) (Wemple draft; Megahan et al. 1992). The longevity of changes in hydrologic processes resulting from forest roads is as permanent as the road. Until a road is removed and natural drainage patterns are restored, the road will likely continue to affect the routing of water through watersheds.

In watersheds on the order of 20-200 square miles, increased peak flows have been detected after roading and clearcutting occurred (Christner and Harr 1982; Jones and Grant in review). Higher flows result from a combination of wetter, more efficient water-transporting soils following reduced evapotranspiration (Harr et al. 1982; Harris 1977), increased snow accumulation and subsequent melt during rainfall (Berris and Harr 1987; Harr 1986; Harr and Coffin 1992) surface runoff from roads (Harr et al. 1975, 1979) extension of drainage networks by roadside ditches (Wemple draft) and possibly reduced roughness of stream channels following debris removal and salvage logging in riparian zones (Jones and Grant in review).

The alteration in stream flow regime resulting from timber harvest and associated activities can have both positive and negative effects on the aquatic system (Hicks, B.J 1991a). For example, decreased evapotranspiration following logging and prior to vegetation regrowth can increase summer stream flows which may bring about short-term increases in juvenile salmonid survival. Conversely, increased peak flows may increase bed-load movement and reduce survival of salmonid eggs and alevins. Effects of streamflow changes on aquatic organisms have not been documented independently from other logging effects. The extent to which the positive effects of short-term increase in summer flows is offset by the detrimental effect of increased peak flows and resultant scour is unknown.

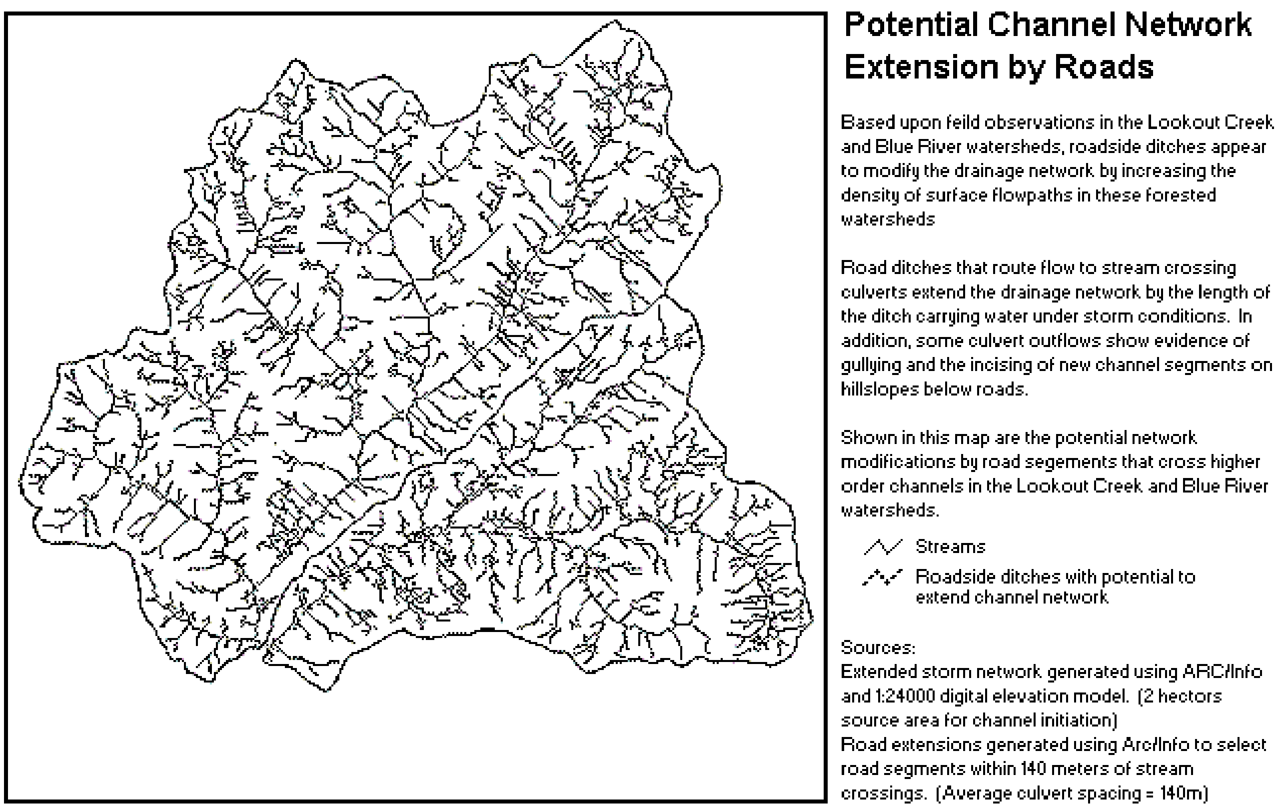

Figure 5-10. Map of potential channel network extension by roads. (B. Wemple, Oregon State University).

Inchannel Habitat

A primary factor influencing the diversity of stream fish communities is habitat complexity. Attributes of habitat diversity include the variety and range of hydraulic conditions (i.e., depths and water velocities) (Kaufmann 1987), number of pieces and size of wood (Bisson et al. 1987), types and frequency of habitat units, and variety of bed substrate (Sullivan et al. 1987). More diverse habitats support more diverse assemblages and communities (Gorman and Karr 1978; Schlosser 1982; Angermeier and Karr 1984). Habitat diversity can also mediate biotic interactions such as competition (Kalleberg 1958; Hartman 1965) and predation (Crowder and Cooper 1982; Schlosser 1988).

Large pools, a primary characteristic of high quality aquatic ecosystems, have been lost in basins that have had varying levels of land management. The number of large, deep pools (i.e., more than 6 feet deep and greater than 50 yards square surface areas) in many tributaries of the Columbia River, have decreased in the past 50 years (Sedell and Everest 1991) (Table 5-3). Over all, there has been a 58 percent reduction in the number of large, deep pools in resurveyed streams on National Forests within the range of the northern spotted owl in western and eastern Washington. A similar trend was found in streams on private lands in coastal Oregon, where large, deep pools decreased by 80 percent. Ralph et al. (unpubl. ms.) reported the loss of pools in streams in basins with moderate (less than 50 percent of the basin harvested in the last 40 years) to intensive (more than 50 percent of the basin harvested within the last 40 years and a road density of more than 5.3 miles per square mile) levels of timber harvest in western Washington. Bisson and Sedell (1984) reported similar results for other streams in western Washington. Primary reasons for the loss of pools are filling by sediments (Megahan 1982), loss of pool-forming structures such as boulders and large wood (Bryant 1980; Sullivan et al. 1987), and loss of sinuosity by channelization (Furniss et al. 1991; Benner 1992).

The Regional Ecosystem Assessment Project of Region 6 of the U.S. Forest Service included pool frequency as a primary indicator of aquatic ecosystem condition. The Region 6 stream inventory or comparable data provided current conditions. Current pool frequency was below the range of natural conditions for most rivers examined (Figure 5-11). For the few rivers in which pool frequency was within the estimated range of natural conditions, the overlap was limited to the lower portion of the range.

Habitat simplification may result from timber harvest activities (Bisson and Sedell 1984; Hicks et al. 1991a; Bisson et al. 1992; Frissel 1992; Ralph et al. unpub. ms.). Timber harvest activities can result in a decrease in the number and quality of pools (Sullivan et al. 1987). Wood is a major habitat-forming element in streams. Reduction of wood in the channel, either from present or past activities, generally reduces pool quantity and quality (House and Boehne 1987; Bisson et al. 1987). Constricting naturally unconfined channels with bridge approaches or streamside roads reduces stream meandering and decreases pools formed by stream meanders that undercut banks (Furniss et al. 1991). Increased mass failures from roads and timber harvest on unstable slopes can result in the loss of pools due to sediment influxes (Morrison 1975; Swanson and Dyrness 1975; Beschta 1978; Swanson et al. 1982b; Ziemer and Swanston 1977; Ketcheson and Froehlich 1978; Marion 1981; Grant and Wolff 1991; Coats 1987; Janda et al. 1975; Kelsey et al. 1981; Madej 1984; Nolan and Marron 1985).

In Pacific Northwest streams, habitat simplification resulting from timber harvest and associated activities leads to a decrease in the diversity of the anadromous salmonid complex (Bisson and Sedell 1984; Li et al. 1987; Hicks 1990; Reeves et al. 1993). One species may increase in abundance and dominance while others decrease. Holtby (1988), Holtby and Scrivener (1989), and Scrivener and Brownlee (1989) in British Columbia and Rutherford et al. (1987) in Oklahoma reported similar responses by fish communities in streams affected by timber harvest activities. Similar patterns have also been observed in streams altered by other anthropogenic activities such as agriculture (Schlosser 1982; Berkman and Rabini 1987) and urbanization (Leidy 1984; Scott et al. 1986).

Changes in the Frequency of Large, Deep Pools...

	Miles Surveyed	1935-1945 Number	Number/ Miles	1987-1992 Number	Numer/ Pool	Percent Change
Western Wahington						
Cascades						
Cowlitz River Basin	52.1	421	8.1	176	3.4	-58%
Lewis River Basin	4.8	22	4.6	13	2.7	-41%
Wind River Basin	35.4	75	2.1	80	2.3	10%
Coastal						
Grays River Basin	20.7	107	5.2	34	1.6	-69%
Elochoman River Basin	21.5	79	3.7	13	0.3	-84%
Abernathy Basin	8.3	3	0.4	3	0.4	-NC
Germany Basin	8.0	7	0.9	4	0.5	-44%
Coweeman River Basin	26.4	87	3.3	4	0.2	-94%
Eastern Washington						
Yakima River Basin	28.5	98	3.4	14	0.5	-85%
Wenatchee River Basin	60.7	143	2.4	125	2.1	-13%
Methow River Basin	119.0	106	0.9	52	0.4	-56%
Coastal Oregon						
Lewis and Clark River	10.4	47	4.5	10	1.0	-78%
Clatskanie River	15.5	135	8.7	20	1.3	-85%

Table 5-3. Changes in the frequency of large, deep pools (>50 yds^2 and >6 feet deep) between 1935 and 1992 in streams on national forest within the range of the northern spotted owl.

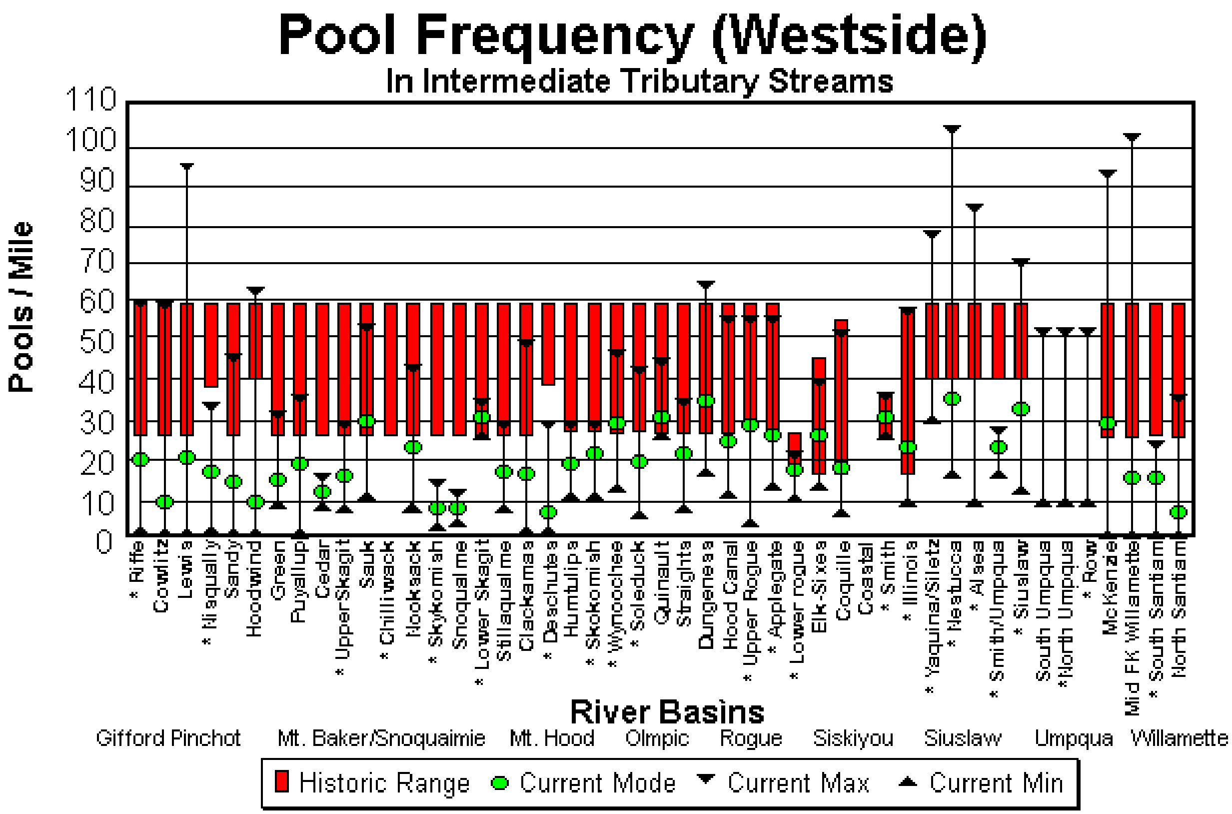

Figure 5-11. Historic range, current range, and current mode of river basin pool frequency in intermediate tributary streams west of the Cascade Mountains in Washington and Oregon. Basins that had limited data are shown by (*). (USDA Forest Service 1993).

Riparian Ecosystem Components

Riparian areas are particularly dynamic portions of the landscape. These areas are shaped by disturbances characteristic of upland ecosystems, such as fire and windthrow, as well as disturbance processes unique to stream systems, such as lateral channel erosion, peakflow, deposition by floods and debris flows. Near-stream, floodplain riparian areas may have plant communities of relatively high diversity (Gregory et al. 1991) and extensive hydrologic and nutrient cycling interactions between groundwater and riparian vegetation.

Riparian vegetation regulates the exchange of nutrients and material from upland forests to streams (Swanson et al. 1982b; Gregory et al. 1991). Fully functional riparian ecosystems have a suite of characteristics which are summarized below. Large conifers or a mixture of large conifers and hardwoods are found in riparian zones along all streams in the watershed, including those not inhabited by fish (Naiman et al. 1992). Riparian zone-stream interactions are a major determinant of large woody debris loading (House and Boehne 1987; Bisson et al. 1987; Sullivan et al. 1987). Stream temperatures and light levels that influence ecological processes are moderated by riparian vegetation (Agee 1988; Gregory et al. 1991). Streambanks are vegetated with shrubs and other low growing woody vegetation. Root systems in streambanks of the active channel stabilize banks, allow development and maintenance of undercut banks, and protect banks during large storm flows (Sedell and Beschta 1991). Riparian vegetation contributes leaves, twigs, and other forms of fine litter that are an important component of the aquatic ecosystem food base (Vannote et al. 1980).

Riparian areas are widely considered to be important wildlife habitat. A distinct microclimate is maintained along stream channels, created by cold air drainage and the presence of turbulent surface waters. Large wood on the ground is an important habitat component in riparian areas. Maintaining the integrity of the vegetation is particularly important for riparian-dependent organisms including amphibians, arthropods, mammals, birds, and bats (see Appendix for greater detail).

Riparian habitat conditions on federal lands within the range of the northern spotted owl have been degraded by road construction and land management activities. For example, coast range riparian areas outside of wilderness areas are nearly all red alder or bigleaf maple because of timber harvest and associated activities. Riparian areas have very few large trees greater than 10 inches diameter growing within 100-200 feet of the stream, suggesting that streamside recruitment of large wood may be deficient for decades.

Riparian Processes as a Function of Distance from Stream Channels

Many effects of riparian vegetation on streams decrease with increasing distance from the streambank (VanSickle and Gregory 1990; McDade et al. 1990; Beschta et al. 1987) (Figure 5-12 and Figure 5-13) and are influenced by the degree of channel constraint and floodplain development (Sparks et al. 1990; Sedell et al. 1989).

Root Strength

The upstream head of steep channels and other steep hillslope areas are common initiation sites of debris slides and debris flows (Dietrich and Dunne 1978). Root strength provided by trees and shrubs contribute to slope stability; and loss of root strength following tree death by timber harvest or other causes may lead to increased incidence of debris slides and flows (Sidle et al. 1985). The soil stabilizing zone of influence for vegetation in these sites is the slide scar width plus half a tree crown diameter (Figure 5-12). Half a tree crown diameter is an estimate of the extent to which root systems of trees adjacent to the slide scar margin affect soil stability. The contribution of root strength to maintaining streambank integrity also declines at distances greater than one-half a crown diameter (Burroughs and Thomas 1977; Wu 1986; and personal communication, F.J. Swanson and T. Spies, Pacific Northwest Research Station, Corvallis, Oregon).

Large Wood Delivery to Streams

The probability that a falling tree will enter the stream is a function of slope distance from the channel in relation to tree height

(VanSickle and Gregory 1990; McDade et al. 1990; Andrus and Lorenzen, 1992; Beschta et al. 1991). The effectiveness of floodplain riparian forests and riparian forests along constrained channels to deliver large wood is low at distances greater than approximately one tree height away from the channel (Figure 5-12).

Large Wood Delivery to Riparian Areas

Large downed logs are recruited into riparian areas from the riparian forests and from upslope forests. Similar to large wood delivery from riparian areas into streams, the effectiveness of upland forests to deliver large wood to the riparian area is naturally expected to decline at distances greater than approximately one tree height from the stand edge (Thomas et al. 1993). Timber harvest adjacent to the riparian area creates an edge that eliminates one source of large wood. Thus, long-term levels of large wood may diminish in the riparian zone.

Leaf and Other Particulate Organic Matter Input

The distance away from the stream from which leaf litter input originates depends on site-specific conditions. Thus, the effectiveness of floodplain riparian forests to deliver leaf and other particulate organic matter declines at distances greater than approximately one-half a tree height away from the channel (Figure 5-12). We are unaware of studies examining litter fall from riparian zones as a function of distance of litter source from the channel. However, Erman et al. (1977) reported that the composition of benthic invertebrate communities in streams with riparian buffers greater than 100 feet were indistinguishable from those in streams flowing through unlogged watersheds. While other factors could have been influencing community structure, in fact, riparian forests of widths equal to or greater than 100 feet retained sufficient litter inputs to maintain biotic community structures in the stream. The curve in this Figure 5-12 is consistent with Erman et al. (1977) and our professional judgment.

Shade

Effectiveness of streamside forest to provide shade varies with topography, channel orientation, extent of canopy opening above the channel, and forest structure, particularly the extent of both under- and overstory. Although, any curve depicting this function is by necessity quite generalized (Figure 5-12), buffer width correlates well with degree of shade (Beschta et al. 1987). In the Oregon Coast Range and western Cascade Mountains riparian buffers of 100 feet or more have been reported to provide as much shade as undisturbed late successional/old-growth forests (Steinblums 1977).

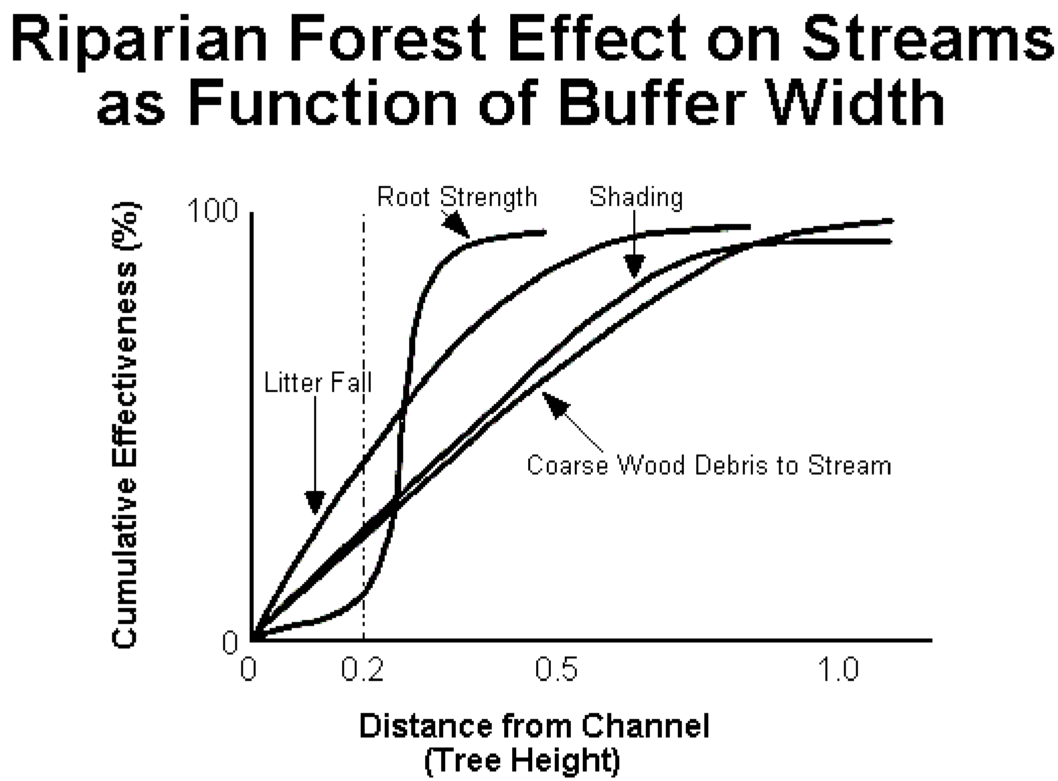

Figure 5-12. Generalized curves indicating percent of riparian ecological functions and processes occurring within varying distances from the edge of a forest stand.

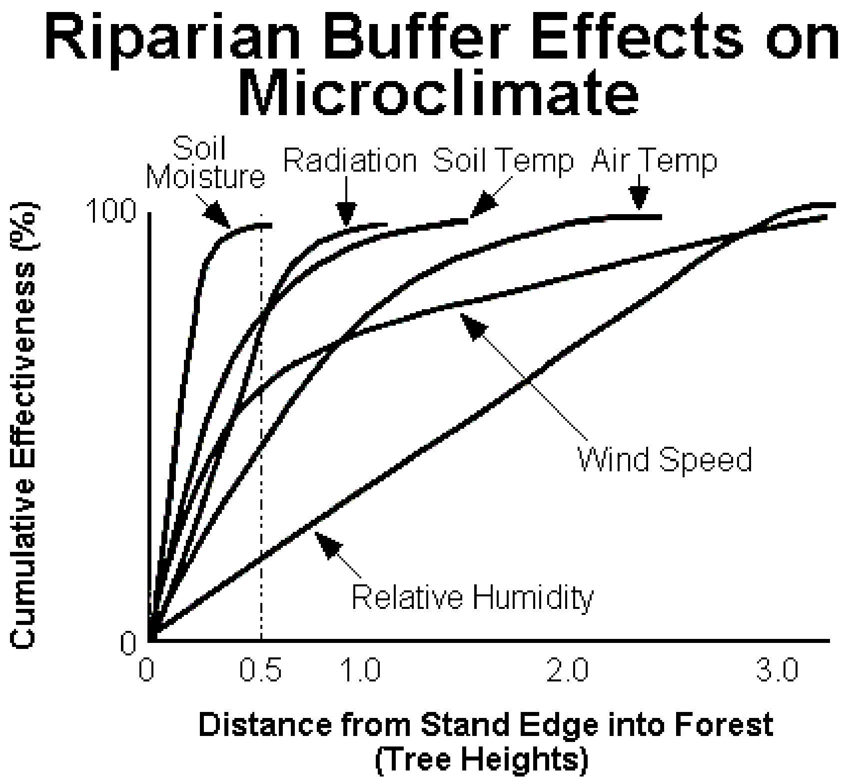

Figure 5-13. Generalized curves indicating percent of microclimatic attributes occurring within varying distances of the edge of a riparian forest stand (after Chen, J 1991).

Riparian Microclimate

Streamside and upslope forest affect microclimate and thereby habitat in the riparian environment. Microclimate is likely influenced by widths of both the riparian area and the stream channel. Riparian zones along larger streams, third-order and greater, consist of two distinct parallel bands of vegetation separated by the stream channel. By contrast, channels of lower order streams are so narrow that a functionally continuous canopy usually exists.

We are aware of no reported field observations of microclimate in riparian zones, but Chen (1991) documented change in soil and air temperature, soil moisture, relative humidity, wind speed, and radiation as a function of distance from a clearcut edge into upslope forest in two Cascades study sites. Patterns vary substantially with season, time of day, edge aspect, and extent of tree removal in the harvested stand. Figure 5-13 shows the maximum effects observed by Chen (1991).

When timber is harvested to the outer limit of the riparian zone, an edge is created that may affect the interior microclimatic conditions of the riparian forest. If the forest is harvested from only one side of a small stream, leaving both riparian areas intact, then the edge effect on the microclimatic conditions within the riparian forest may be comparable to that demonstrated in upland forests (Figure 5-13).

Removing upland forest from both sides of the riparian zone of a small stream, creates two edges, and the effect on microclimatic conditions may be additive, if not synergistic. The degree to which the two edge effects are additive depends on the total width of the riparian corridor and is probably influenced by season, time of day, aspect, channel orientation, and extent of tree removal from the harvested stand. This situation is somewhat analogous to harvesting the forest adjacent to the riparian area along a larger river. When this forest is removed, the riparian area of a larger river becomes a corridor with two edges, one created by the river channel itself and one resulting from timber harvest. Thus, buffers may need to be wider to maintain interior microclimatic conditions than other riparian functions.

Water Quality

Castelle et al. (1992) provide a thorough literature review of widths of riparian areas required to protect water quality functions. In general, the authors found that widths of riparian areas required to protect water quality ranged from 12-860 feet. Widths varied as a function of geomorphic characteristics such as slope and soil type and by vegetative structure and cover. Effectiveness of buffers at improving water quality adjacent to logging operations was studied by Broderson (1973), Darling et al. (1982), Lynch et al. (1985), and Corbett and Lynch (1985). Broderson studied three watersheds in western Washington and found that 200 foot buffers, or about one site-potential tree height, would be effective to remove sediment in most situations if the buffer were measured from the edge of the floodplain.

Wildlife Habitat

The Washington Department of Wildlife (1992) recommended wetland buffer widths for protection of wildlife species in that state. Roderick and Milner (1991) also prescribe wildlife protection buffer requirements for wetlands and riparian habitats in Washington. These widths vary from 100 to 600 feet depending on species and habitat usage. See Appendix for greater detail.

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Aquatic Conservation Strategy

This conservation strategy is aimed at restoring and maintaining the ecological health of watersheds (Karr et al. 1986, Karr 1991, Naiman et al. 1992). The strategy was designed to provide a scientific basis for protecting aquatic ecosystem and enables planning for sustainable resource management. It is a region wide strategy seeking to retain, restore, and protect those processes and landforms that contribute habitat elements to streams and promote good habitat conditions for fish and other aquatic and riparian dependent organisms. The foundation of the conservation strategy is a refinement of the approach outlined in Thomas et al. (1993). All options under consideration, with the exception of Option 7, utilize one of three scenarios derived from this conservation strategy. These are referred to as Riparian Reserve 1, Riparian Reserve 2, and Riparian Reserve 3 and will be discussed in detail below.

An effective conservation strategy must protect aquatic ecosystem functions and processes, organized at a watershed scale, while recognizing that land ownership patterns rarely coincide with the distinct topographic boundaries of watersheds. Any conservation strategy that attempts to protect all components of the aquatic ecosystem ranging from landslides areas in the uplands to mainstem riparian forests must be extensive and comprehensive. Decision criteria for protection, monitoring and restoration must be included.

At the heart of this approach is the recognition that fish and other aquatic organisms evolved within a dynamic environment that has been constantly influenced and changed by geomorphic and ecologic disturbances. Stewardship of aquatic resources has the highest likelihood of protecting biological diversity and productivity when land use activities do not substantially alter the natural disturbance regime to which these organisms are adapted (Swanson et al. in press).

This conservation strategy employs several tactics with which to approach the goal of maintaining the "natural" disturbance regime. Land use activities need to be limited or excluded in parts of the watershed prone to instability. The distribution of land-use activities, such as timber harvest or roads, must minimize increases in peak streamflows. Headwater riparian zones need to be protected, so that when debris slides and flows occur they contain large wood and boulders necessary for creating habitat farther downstream. Riparian zones along larger channels need protection to limit bank erosion, ensure an adequate and continuous supply of large wood to channels, and provide shade and microclimate protection. Watersheds currently containing the best habitat or with the greatest potential for recovery shall receive increased protection and be priorities for restoration programs.

Current scientific understanding of fish habitat relationships is inadequate to allow definition of specific habitat requirements for fish throughout their life cycle at the watershed level. Some general habitat needs of fish are well known, such as deep resting pools, cover, certain temperature ranges, food supply, and clean gravels for spawning (Bjornn and Reiser 1991). However, we cannot specify how these habitats and conditions should be distributed through time and space to provide for fish needs. In natural watersheds, different species and age classes interact with multiple habitat elements in complex ways. This interaction occurs within a landscape where the quality and distribution of habitat elements change with time in relation to disturbance processes and land-use imposed changes on streams and riparian zones.

We believe that any species-specific strategy aimed at defining explicit standards for habitat elements would be insufficient for protecting even the targeted species. To succeed, any Aquatic Conservation Strategy must strive to maintain and restore ecosystem health at watershed and landscape scales. Thus, this is the approach the conservation strategy proposed here employs. This approach seeks to prevent further degradation and restore habitat over broad landscapes as opposed to individual projects or small watersheds. We emphasize, however, that **it will require time for this strategy to work**. Because it is based on natural disturbance processes, it may take decades to over a century to accomplish all of its objectives. Some improvements in aquatic ecosystems, however, can be expected in 10 to 20 years. We believe that if this approach is conscientiously implemented, it will protect habitat for fish and other riparian dependent species resources and restore currently degraded habitats.

Aquatic Conservation Strategy Objectives

Federal lands within the range of the northern spotted owl shall be managed to:

1. Maintain and restore the distribution, diversity, and complexity of watershed and landscape-scale features to ensure protection of the aquatic systems to which species, populations and communities are uniquely adapted.

2. Maintain and restore spatial and temporal connectivity within and between watersheds. Lateral, longitudinal, and drainage network connections include floodplains, wetlands, upslope areas, headwater tributaries, and intact refugia. These linages must provide chemically and physically unobstructed routes to areas critical for fulfilling life history requirements of aquatic and riparian-dependent species.

3. Maintain and restore the physical integrity of the aquatic system, including shorelines, banks, and bottom configurations.

4. Maintain and restore water quality necessary to support healthy riparian, aquatic, and wetland ecosystems. Water quality must remain in the range that maintains the biological, physical, and chemical integrity of the ecosystem, benefiting survival, growth, reproduction, and migration of individuals composing its aquatic and riparian communities.

5. Maintain and restore the sediment regime which the aquatic system evolved. Elements of the sediment regime include the timing, volume, rate, and character of sediment input, storage, and transport.

6. Maintain and restore in-stream flows sufficient to create and sustain riparian, aquatic, and wetland habitats and to retain patterns of sediment, nutrient, and wood routing. The timing, magnitude, duration, and spatial distribution of peak, high, and low flows must be protected.

7. Maintain and restore the timing, variability, and duration of floodplain inundation and water table elevation in meadows and wetlands.

8. Maintain and restore the species composition and structural diversity of plant communities in riparian zones and wetlands to provide adequate summer and winter thermal regulation, nutrient filtering, appropriate rates of surface erosion, bank erosion, and channel migration and to supply amounts and distributions of large wood sufficient to sustain physical complexity and stability.

9. Maintain and restore habitat to support well-distributed populations of native plant, invertebrate, and vertebrate riparian-dependent species.

Quantifiable Objectives for Desired Conditions

Relationships between long-term trends in aquatic system degradation and the effects of forest management practices are well known, but quantitative relationships have been difficult to establish (Hicks et al. 1991a, Bisson et al. 1992). Due to inherent differences in stream size, storm magnitude, and geology, similar management practices may result in a different response (Hicks 1990). In addition, extended time periods and triggering climatic event may be required before the effects of land management are expressed in streams.

The wide range of natural variation of individual stream habitat variables and the complex, and little understood interplay between these (e.g., numbers of pools and pieces of large wood, percent fine sediment, and water temperature) makes it difficult to establish relevant quantitative management directives for habitat features. It is also difficult to quantify direct linkages among processes and functions outside the stream channel to in channel conditions and biological variables.

Structural components of stream habitat must not be used as management goals in and of themselves. No target management or threshold level for these habitat variables can be uniformly applied to all streams. While this approach is appealing in its simplicity, it does not allow for natural variation among streams (Gregory et al. 1991; Rosgen 1988; Ralph et al. unpub. ms.). Furthermore, attaining the predetermined value does nothing to insure aquatic ecosystem processes are protected. These habitat parameters must be viewed collectively as part of the larger issue of watershed health and maintenance of natural physical and biological integrity (Karr 1991; Naiman et al. 1992).

An interagency effort, between the U.S. Forest Service and the Bureau of Land Management, is developing a strategy for maintaining and restoring anadromous fish habitat and watersheds. This project is establishing quantifiable objectives for desired conditions. The group is using empirical data and theoretical models to arrive at quantifiable channel, water, and riparian conditions. At the regional level, such quantifiable objectives may be appropriate to set direction for planning. However, we believe that watershed-specific objectives are necessary to accommodate natural variability along the stream network.

Components of the Strategy

The basic components of the Aquatic Conservation Strategy are:

1. **Riparian Reserves**: Lands along streams and unstable areas where special Standards and Guidelines govern land-use.

2. **Key Watersheds**: A system of large refugia comprising watersheds that are crucial to at-risk fish species and stocks and for high quality water.

3. **Watershed analysis**: Procedures for conducting analysis that evaluate geomorphic and ecologic processes operating in specific watersheds. This should enable watershed planning that achieves Aquatic Conservation Strategy Objectives. Watershed analysis provides the basis for monitoring and restoration programs and the foundation from which Riparian Reserves can be delineated.

4. **Watershed Restoration**: A comprehensive, long-term program of watershed restoration to restore watershed health, riparian ecosystems, and fish habitats.

These components are designed to operate together to maintain and restore the productivity and resilience of riparian and aquatic ecosystems. They will not achieve the desired results if implemented alone or in some limited combination.

Each of the options developed for managing federal lands within the range of the northern spotted owl (described in Chapter 3), include a set of Late-Successional Reserves. Total area in Late-Successional Reserves varied from 5-9 million acres depending on the option (Table 5-4). While these reserves were not derived for the Aquatic Conservation Strategy, they are an important component. They confer two major benefits to fish habitat and aquatic ecosystems. First, the Standards and Guidelines under which Reserves are managed limit activity in these areas; providing increased protection for all stream types. Second, since these Reserves possess late-successional characteristics, they tend to be relatively undisturbed areas although some management may have taken place in them in the past. Some Reserves offer core areas of good stream habitat in predominantly degraded landscapes that will act as refugia and centers from which degraded areas can be recolonized as they recover. Streams in these Reserves may be particularly important for endemic or locally distributed fish species and stocks.

Riparian Reserves

Riparian Reserves are portions of watersheds where riparian-dependent resources receive primary emphasis and where special Standards and Guidelines (Appendix) apply. Riparian Reserves include those portions of a watershed that are directly coupled to streams and rivers, that is, the portions of a watershed required for maintaining hydrologic, geomorphic, and ecologic processes that directly affect streams, stream processes, and fish habitats. Riparian Reserves include the more common land resource management riparian management zones or streamside management zones and primary source areas for wood and sediment such as landslides and landslide-prone slopes in headwater areas and along streams.

Riparian Reserves generally parallel the stream network but also include other areas necessary for maintaining hydrologic, geomorphic, and ecologic processes. Riparian habitat conditions on federal lands within the range of the northern spotted owl have been degraded by road construction and land management activities.

Land Allocations by Option in Millions of Acres

Option	1	2	3	4	5	6	7	8	9	10
Congressionally Withdrawn	6.98	6.98	6.98	6.98	6.98	6.98	6.98	6.98	6.98	6.98
Late-Successional Reserve	11.50	8.92	8.04	8.41	6.86	7.52	5.91	7.52	7.05	7.52
Riparian Reserve	1.87	1.99	2.12	2.88	2.65	2.29	0.62	1.50	2.23	2.29
Administratively Withdrawn	1.08	1.52	1.68	1.66	2.08	1.83	2.29	1.83	1.65	1.83
Matrix	2.83	4.85	4.59	4.33	5.69	5.64	8.46	6.43	4.86	5.64
Managed Late-Successional	--	--	0.85	--	--	--	--	--	--	--
Adaptive Management Areas	--	--	--	--	--	--	--	--	1.49	--
Total	**24.26**	**24.26**	**24.26**	**24.26**	**24.26**	**24.26**	**24.26**	**24.26**	**24.26**	**24.26**

Table 5-4. Land allocations by option in millions of acres.

Every watershed in National Forests and Bureau of Land Management Districts within the range of the northern spotted owl will have Riparian Reserves. Land allocated to Riparian Reserve status varies between options from 0.62 to 2.88 million acres (Table 5-4). It is important to note that the Riparian Reserve acreage is calculated only for land outside the Late-Successional Reserves and Congressionally Withdrawn Areas, thus if two options have identical interim widths for Riparian Reserves, the option with the larger Late-Successional Reserve system will have less Riparian Reserve acreage. For example, Options 1 and 4 both have interim Riparian Reserves of identical widths, but Option 1 has a much larger Late-Successional Reserve system and thus appears to have fewer acres in Riparian Reserves.

Maintaining the connectivity of all parts of the aquatic ecosystem is necessary for healthy watersheds and good fish habitat (Naiman et al. 1992). First- and second-order streams (Strahler 1957), which generally include permanently flowing nonfish-bearing streams and seasonally flowing or intermittent streams, often comprise over 70 percent of the cumulative channel length in mountain watersheds in the Pacific Northwest (Benda et al. 1992). These streams are sources of water, nutrients, wood, and other vegetative material for streams inhabited by fish and other aquatic organisms (Swanson et al. 1982b; Benda and Zhang 1990; Vannote et al. 1980). Decoupling the stream network can result in the disruption and loss of functions and processes necessary for creating and maintaining fish habitat. Under this conservation strategy, Riparian Reserves are used, in part, to maintain and restore riparian structures and functions of intermittent streams.

Riparian Reserves will confer benefits to riparian-dependent and associated species other than fish. They will enhance habitat conservation for organisms that are dependent on the transition zone between upslope and riparian areas. Improved travel and dispersal corridors for many terrestrial animals and plants and a greater connectivity of the watershed should also result from establishment of Riparian Reserves.

Tree heights and slope distance provide ecologically appropriate metrics with which to establish Riparian Reserve widths. For example, tree height distance away from the stream is a better indicator of potential wood recruitment or degree of shade than is an arbitrary distance. Likewise, slope distance is a more meaningful ecological distance than horizontal distance.

Thomas et al. (1993) used specified widths, geomorphic features, or a distance equal to the height of a site-potential tree to delineate riparian areas. They defined a site-potential tree as a tree that has attained the maximum height possible given the site conditions where it occurs. We redefined the height of a site-potential tree as the average maximum height of the tallest dominant trees (200 years or more) for a given site class. Johnson et al. (1991) used data collected in a 1978 Bureau of Land Management riparian forest inventory to estimate this height for various sites. National Forests and Bureau of Land Management Districts identified the site classes of riparian areas on lands under their jurisdiction. For all forests west of the Cascades, except the Siuslaw National Forest, site-class IV was used. The height of a site-potential tree in these areas was 170 feet. The Siuslaw National Forest was classified as a site-class II for which a site-potential tree was 250 feet. The height of site-potential trees on forests east of the Cascades was estimated at 110 feet. These heights were used to delineate interim widths of Riparian Reserves for analysis purposes. Further analysis of plots from forest inventories for the Siuslaw, Willamette, and Olympic National Forests indicate the tallest tree heights were about 10 percent less than in the Bureau of Land Management riparian inventory. Forest-specific riparian inventories are needed to better determine the height of a site-potential tree for a given area. Tree heights used in this effort are probably an upper limit (See Johnson et al. 1991 further details.)

Prescribed widths for Riparian Reserves of different waterbodies were determined based on several ecological and geomorphic factors. Watershed analysis will identify critical hillslope, riparian, and channel processes that must be evaluated in order to delineate Riparian reserves that assure protection of riparian and aquatic functions. Project level considerations of these processes and features will be the basis on which site-specific Riparian Reserves are delineated. We have established a set of interim widths of Riparian Reserves for all watersheds that apply until watershed analysis is completed, a site-specific analysis is conducted and described, and the rationale for final Riparian Reserve boundaries is presented. Interim widths are designed to provide a high level of fish habitat and riparian protection until watershed and project analysis can be completed.

Five types of streams or water bodies and interim widths of Riparian Reserves for each are:

> *Fish bearing streams* - Riparian Reserves consist of the stream and the area on either side of the stream extending from the edges of the active stream channel to the top of the inner gorge, or to the outer edges of the 100 year floodplain, or to the outer edges of riparian vegetation, or to a distance equal to the height of two site potential trees, or 300 feet slope distance (600 feet, including both sides of the stream channel), whichever is greatest. This is the same in all Riparian Reserve scenarios.

Permanently flowing nonfish-bearing streams - Riparian Reserves consist of the stream and the area on either side of the stream extending from the edges of the active stream channel to the top of the inner gorge, or to the outer edges of the 100 year floodplain, or to the outer edges of riparian vegetation, or depending upon the Riparian Reserve scenario - a distance equal to the height of some fraction of a site potential tree, or a specified slope distance (Table 5-5), whichever is greatest.

Constructed ponds and reservoirs, and wetlands greater than 1 acre - Riparian Reserves consist of the body of water or wetland and the area from the outer edges of the riparian vegetation, or to the extent of seasonally saturated soil, or to the extent of moderately and highly unstable areas, or to a distance equal to the height of one site potential tree, or 150 feet slope distance for wetlands greater than 1 acre, and from the edge of the maximum pool elevation of constructed ponds and reservoirs, whichever is greatest. This is the same in all Riparian Reserve scenarios.

Lakes and natural ponds - Riparian Reserves consist of the body of water or wetland and the area from the outer edges of the riparian vegetation, or to the extent of seasonally saturated soil, or to the extent of moderately and highly unstable areas, or to a distance equal to the height of two site potential trees, or 300 feet slope distance, whichever is greatest. This is the same in all Riparian Reserve scenarios.

Seasonally flowing or intermittent streams, wetlands less than 1 acre, and unstable and potentially unstable areas - This category applies to features with high variability in size and site specific characteristics. At a minimum, the Riparian Reserve must include:

> The extent of unstable and potentially unstable areas.
>
> The stream channel and extend to the top of the inner gorge.
>
> The stream channel or wetland and the area from the edges of the stream channel or wetland to the outer edges of the riparian vegetation.

Depending upon the Riparian Reserve scenario, extension from the edges of the stream channel to a distance equal to the height of some fraction of a site potential tree, or a specified slope distance, whichever is greatest (Table 5-5).

Three scenarios were developed that define Interim Widths of Riparian Reserves (Table 5-5). These scenarios differ with respect to Interim widths for streams in Key and non-Key Watersheds (see Key Watershed discussion that follows). These scenarios are components of the set of options defined in Chapter 3. Interim widths of Riparian Reserves on permanently flowing, fish-bearing streams are identical for all three scenarios. For permanently flowing, nonfish-bearing streams, interim widths for scenarios 1 and 2 are identical, while those for scenario 3 are defined as one half that of the other two.

The greatest difference among scenarios is in interim widths defined for intermittent streams. In both Riparian Reserve scenarios 1 and 3 the interim widths on intermittent streams do not vary between Key and non-Key Watersheds. However, the interim widths for these streams prescribed in scenario 1 are six times greater than in scenario 3 (Table 5-5). In Riparian Reserve scenario 2, interim widths within Tier 1 Key Watersheds are the same as in scenario 1. In all other watersheds, scenario 2 widths are one half those defined for scenario 1.

Intermittent Streams

Intermittent streams are an important, and often over-looked, component of aquatic ecosystems (Naiman et al. 1992). Intermittent streams are defined as any non-permanently flowing drainage features having a definable channel and evidence of annual scour or deposition. This includes what are sometimes referred to as ephemeral streams if they meet these two criteria. Several important ecological processes occur in them, including storage and processing of organic materials, the products of which are later transported to downstream areas. Intermittent streams store sediment and wood and are sources of these materials for permanently flowing streams. Removing the connection between intermittent and permanently flowing streams may have detrimental consequences to the physical and biological components of stream ecosystems, particularly in the long-term.

Table 5-5. Minimum widths of Riparian Reserves expressed as whichever slope distance is greatest. In addition, Riparian Reserves must include the 100-year floodplain, inner gorge, unstable and potentially unstable areas. See text for other criteria used to determine Riparian Reserve widths. Options to which Riparian Reserve scenario apply are also listed.

Riparian Reserve Scenario	Stream class	Tier 1 Key watershed	Tier 2 Key watershed	All other watersheds
Riparian Reserve 1 Options 1,4	Fish Bearing Streams	Average Height of Two Site Potential Trees or 300 Feet	Average Height of Two Site Potential Trees or 300 Feet	Average Height of Two Site Potential Trees or 300 Feet
Riparian Reserve 1 Options 1,4	Permanently Flowing Non-Fish Bearing Streams	Average Height of One Site Potential Tree or 150 Feet	Average Height of One Site Potential Tree or 150 Feet	Average Height of One Site Potential Tree or 150 Feet
Riparian Reserve 1 Options 1,4	Intermittent Streams	Average Height of One Site Potential Tree or 100 Feet	Average Height of One Site Potential Tree or 100 Feet	Average Height of One Site Potential Tree or 100 Feet

Riparian Reserve 2 Options 2,3,5,6,9,10	Fish Bearing Streams	Average Height of Two Site Potential Trees or 300 Feet	Average Height of Two Site Potential Trees or 300 Feet	Average Height of Two Site Potential Trees or 300 Feet
Riparian Reserve 2 Options 2,3,5,6,9,10	Permanently Flowing Non-Fish Bearing Streams	Average Height of One Site Potential Tree or 150 Feet	Average Height of One Site Potential Tree or 150 Feet	Average Height of One Site Potential Tree or 150 Feet
Riparian Reserve 2 Options 2,3,5,6,9,10	Intermittent Streams	Average Height of One Site Potential Tree or 100 Feet	Average Height of One Site Potential Tree or 100 Feet	Average Height of One Site Potential Tree or 100 Feet
Riparian Reserve 3 Option 8	Fish Bearing Streams	Average Height of Two Site Potential Trees or 300 Feet	Average Height of Two Site Potential Trees or 300 Feet	Average Height of Two Site Potential Trees or 300 Feet
Riparian Reserve 3 Option 8	Permanently Flowing Non-Fish Bearing Streams	Average Height of Two Site Potential Trees or 75 Feet	Average Height of Two Site Potential Trees or 75 Feet	Average Height of Two Site Potential Trees or 75 Feet

Riparian Reserve 3 Option 8	Intermittent Streams	Average Height of Two Site Potential Trees or 25 Feet	Average Height of Two Site Potential Trees or 25 Feet	Average Height of Two Site Potential Trees or 25 Feet

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Intermittent streams and adjacent areas are often the lands prone to slope stability problems in a watershed. Protection of intermittent streams is important for preventing increased rate and frequency of landslides in time and space, preventing accelerated surface and fluvial erosion, providing habitat for species unique to small stream riparian areas, and maintaining the landslide- and flood-delivered supplies of large woody material throughout the landscape.

The width of Riparian Reserves necessary to protect the ecological integrity of intermittent streams varies with slope and rock type. Figure 5-14 shows the estimated size of Riparian Reserves necessary to protect the ecological values of intermittent streams with different slope and rock types. These estimates were made by geomorphologists, hydrologists, and fish biologists from the Bureau of Land Management, U.S. Forest Service, and the U.S. Environmental Protection Agency. These distances are consistent with the height of 1 site-potential tree discussed previously.

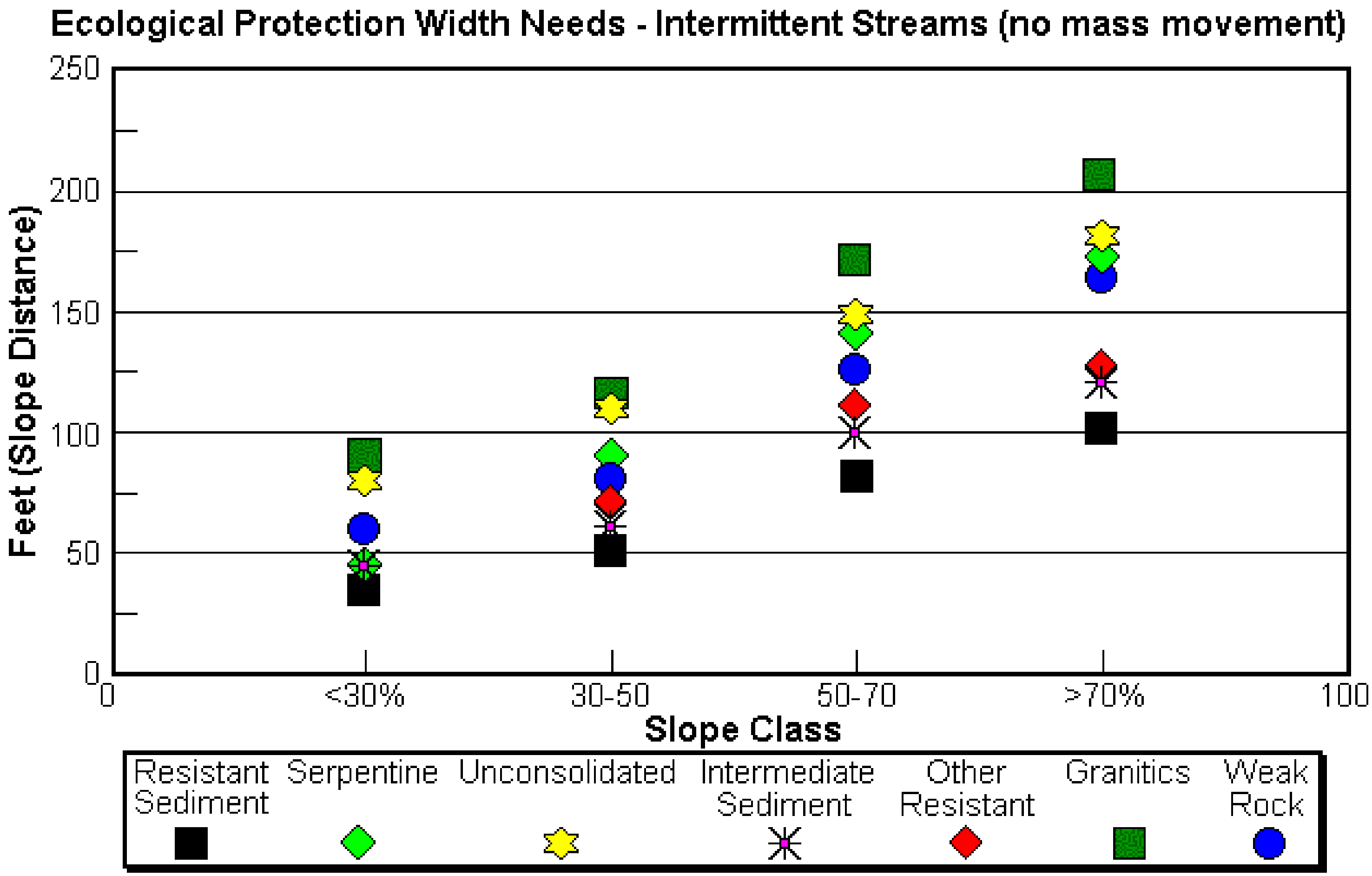

Figure 5-14. Ecological protection needs for intermittent streams, by slope class and rock type. Values are the widths, and slope distance of streamside protection area needed for reasons other than slope stability as estimated by an interagency team of scientists based on professional judgment and experience. Protection needs included surface erosion of streamside slopes, fluvial erosion of the stream channel, soil productivity, habitat for riparian-dependent species, the ability of streams to transmit damage downstream, and the role of streams in the distribution of large wood to downstream fish-bearing waters.

The extent of intermittent streams on public lands is difficult to determine because: (1) no systematic inventory has been conducted using consistent criteria for defining or delineating channels on topographic maps; (2) topographic maps show many of the larger scale declivities in the landscape, but not all declivities are streams and not all streams that exist are shown on the maps; and (3) field inventory of the extent of intermittent streams is costly and the variability is so high that broad extrapolations to unsampled areas is questionable.

Both the Bureau of Land Management and U.S. Forest Service have estimates of the number of intermittent stream miles on lands under their jurisdiction but agency hydrologists believe these to be low. For this current effort, we sampled selected watersheds from National Forests and Bureau of Land Management Districts to estimate miles of intermittent channels. Using this procedure (described fully in this Appendix) we estimate densities of intermittent streams on federal lands within the range of the northern spotted owl that are about 90 percent greater than previously estimated by the agencies.

Examples of Extent of Riparian Reserves and Riparian Areas

Interim Riparian Reserves vary with Riparian Reserve scenario. The interim Riparian Reserve network under the scenarios 1 and 2 are demonstrated for Augusta Creek, Oregon in Figure 5-15 and Figure 5-16. Riparian Reserve scenario 2 is for non-Key Watersheds only. In addition, riparian areas similar to those used in Bureau of Land Management Land Management Plans and the Willamette National Forest Plan are displayed for Augusta Creek in Figure 5-17 and Figure 5-18, respectively.

Drainage basin area included within Interim Riparian Reserves and riparian areas varies among the management alternatives considered, ranging from 8.5 to 53 percent (Table 5-6). The major difference between management alternatives is due to the amount of intermittent streams included and the width of prescribed area along these streams.

Watershed analysis provides the ecological and geomorphic basis for changing the size and location of Interim Riparian Reserves. Figure 5-19 illustrates how slope-stability and debris flow runout models may be used as part of watershed analysis in establishing Riparian Reserves. The result is that the basin is stratified into areas that may require wider or narrower Riparian Reserves than those prescribed for the interim. For example, on intermittent streams in unstable areas with high potential to generate slides and debris flows, Riparian Reserves wider than those prescribed for the interim may be necessary to ensure ecological integrity. Riparian Reserves in more stable areas may be less extensive, managed under upland standards and guides (e.g., levels of green tree retention as either single trees or in specified size patches), or a combination of these. The ultimate design of Riparian Reserves is likely to be a hybrid of decisions based on consideration of sites of special ecological value, slope stability, and natural disturbance processes.

Within a given physiographic province, similar geographic and topographic features control drainage network and hillslope stability patterns. These features may exert a strong influence on design of Riparian Reserves. For example, in the highly dissected southern Oregon Coast Range, debris flows originating in channel heads are the primary mass movement process. Large, slow-moving earthflows are dominant in the western Oregon Cascades. To adequately protect the aquatic system from management induced landsliding, riparian reserve design may vary as a result of these differences. In the Coast Range, Riparian Reserves would tend to be in narrow bands associated with intermittent streams, relatively evenly distributed throughout the basin, while those in the Cascades may be locally extensive and centered around earthflows. Stable areas in other parts of the watershed may have reduced Riparian Reserves on intermittent streams.

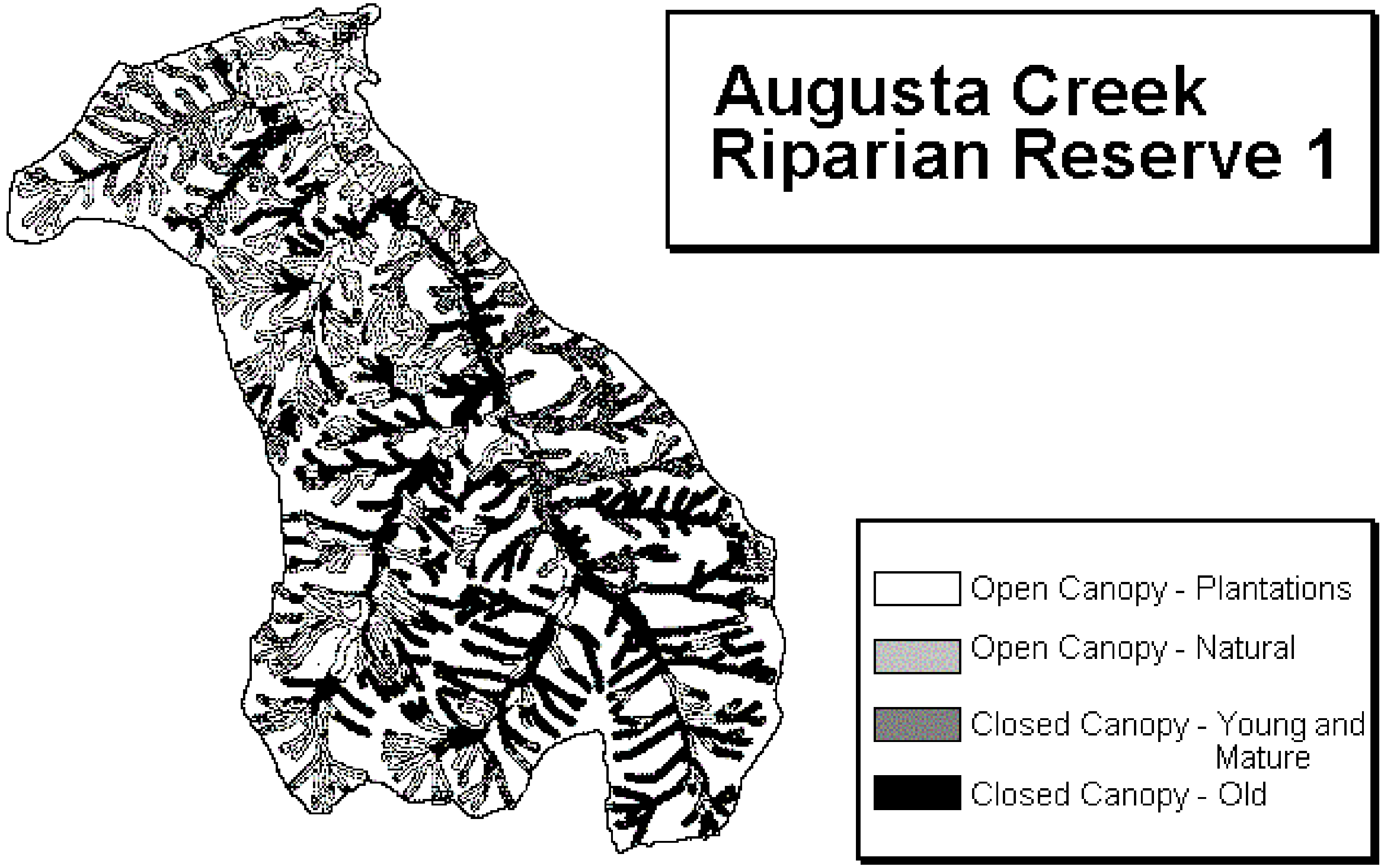

Figure 5-15. Augusta Creek watershed with Riparian Reserves 1.

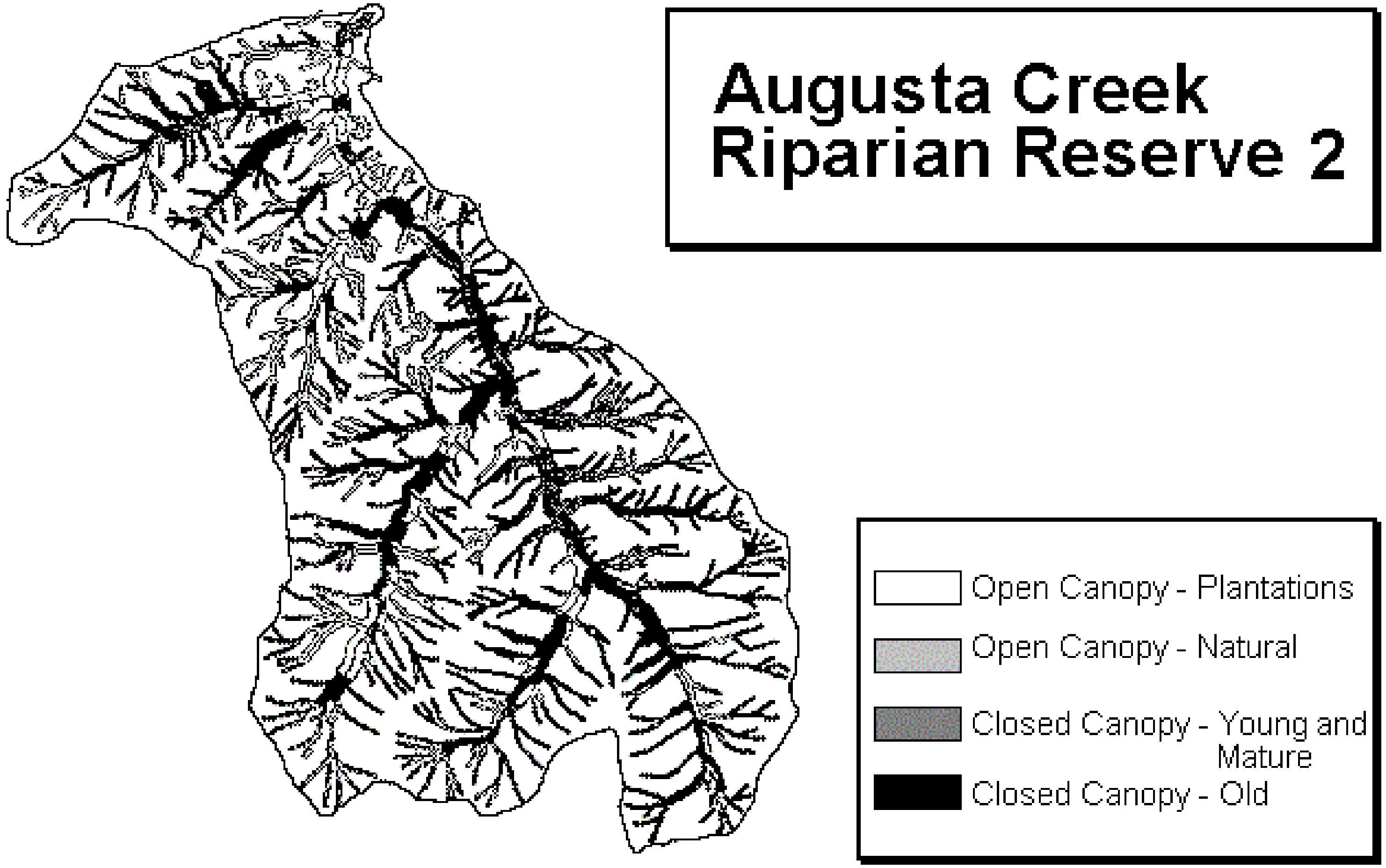

Figure 5-16. Augusta Creek watershed with Riparian Reserves 2.

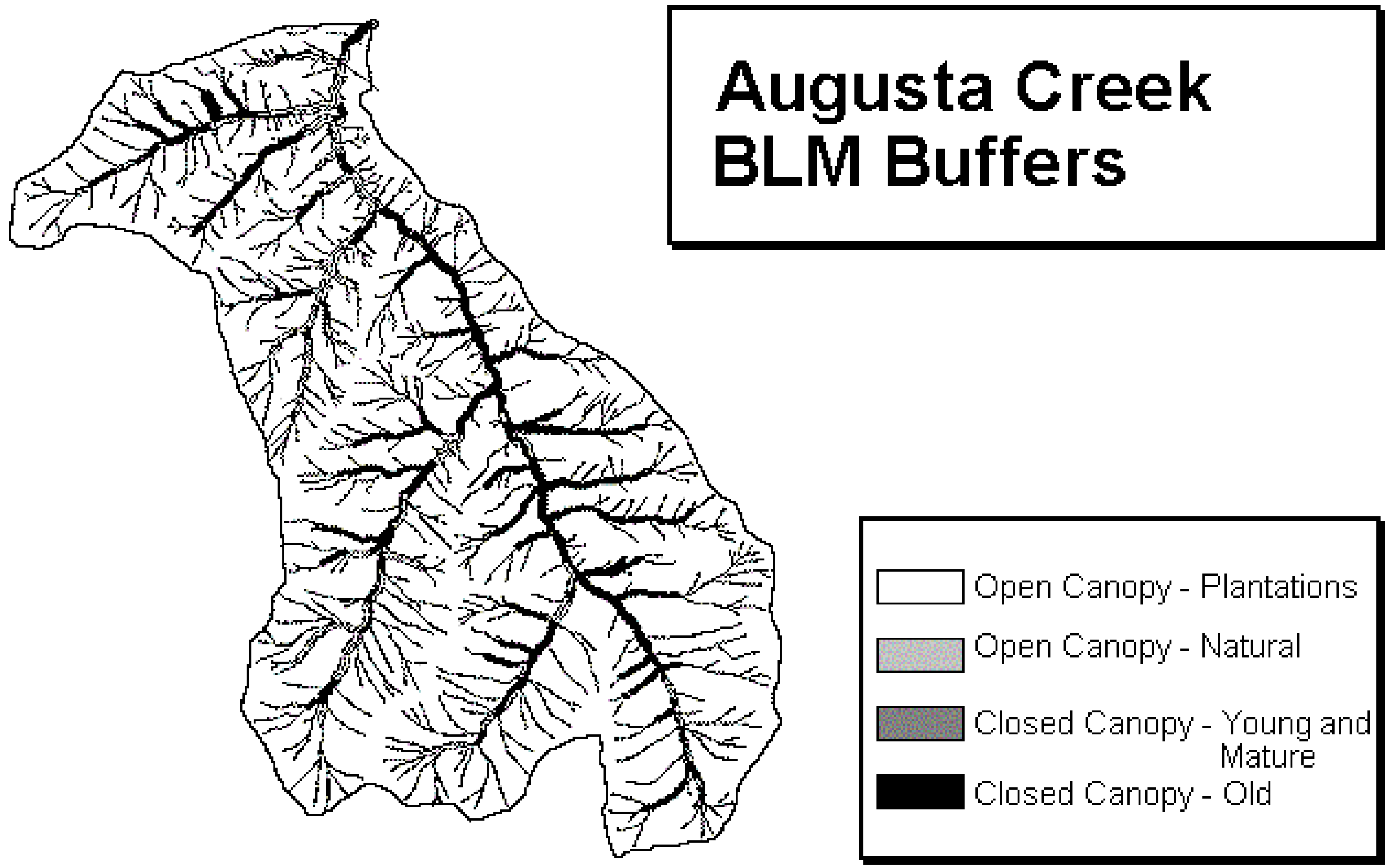

Figure 5-17. Augusta Creek watershed with riparian buffers from proposed Bureau of Land Management plans.

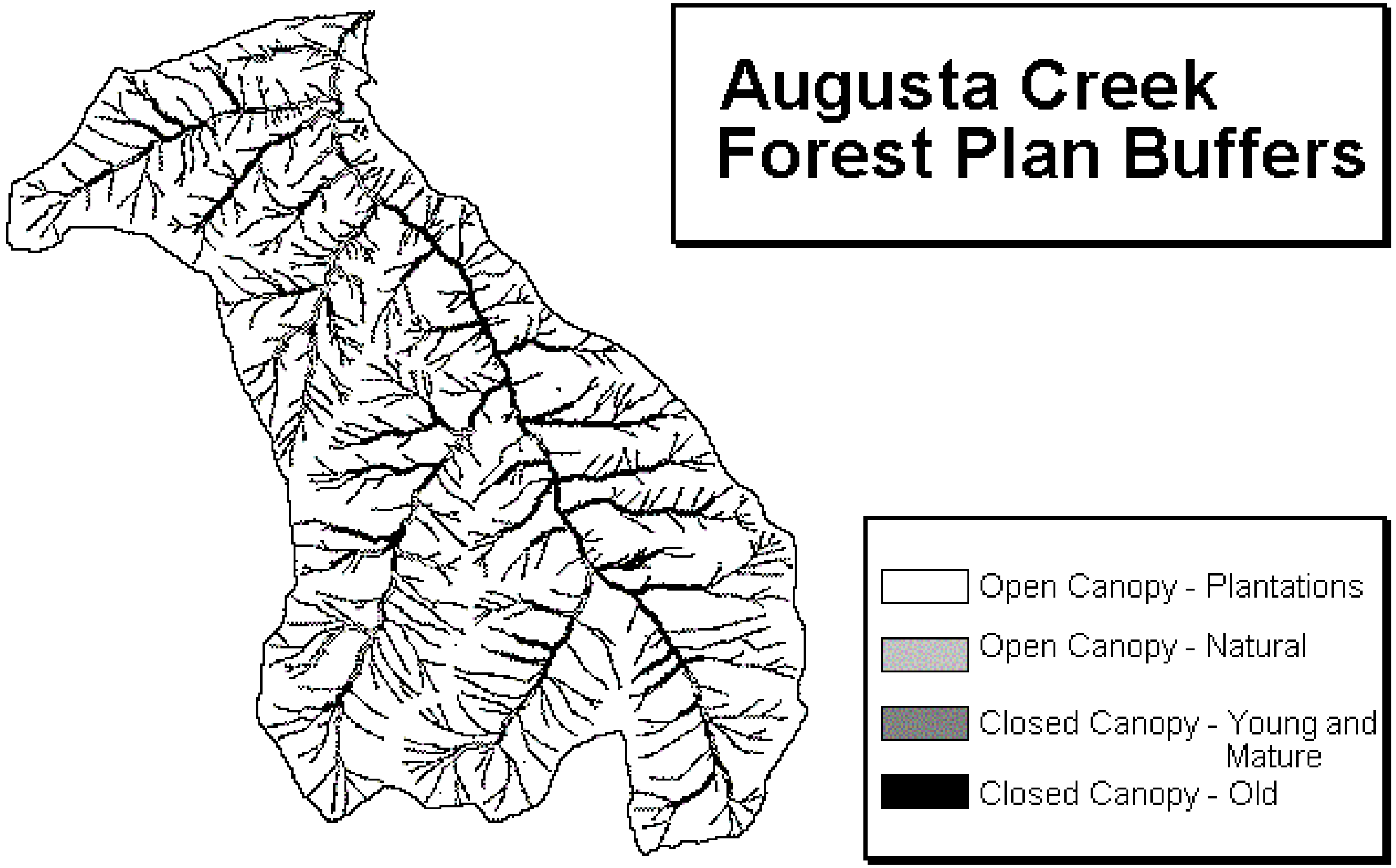

Figure 5-18. Augusta Creek watershed with riparian buffers from the Willamette National Forest plan.

Riparian Reserve Widths
(One Side of Stream)

Stream Category	Interior Widths (feet) of Riparian Reserve and Riparian Areas			
	Bureau of Land Management	Willamette National Forest Plan	Riparian Reserve 2 Non-Key Watershed	Riparian Reserve 1
High value, permanently flowing, fish bearing	225	200	340	340
Lower value, permanently flowing, fish bearing	150	100	340	340
Permanently flowing, non-fish bearing	100	100	170	170
Intermittent	0	25	85	170
Recent of area in Riparian Reserves or riparian areas	8.5	14	36	53

Table 5-6. Riparian Reserve widths (one side of stream). Percent of basin area in Riparian Reserves or Areas are from Augusta Creek, Oregon.

We emphasize that the interim widths for Riparian Reserves are applied to all streams on National Forest and Bureau of Land Management lands within the range of the northern spotted owl until a watershed analysis can be completed. Watershed analysis is expected to yield the contextual information needed to define ecologically and geomorphically appropriate Riparian Reserves. Analysis of site specific characteristics may warrant Riparian Reserves that are narrower or wider than the interim widths. Although Riparian

Reserve boundaries may be adjusted on permanently flowing streams, we consider the interim widths to approximate those necessary for attaining Aquatic Conservation Strategy Objectives. As we have demonstrated, intermittent streams may be highly variable in the degree to which a particular stream affects the hydrologic, geomorphic and ecologic processes in a watershed. Thus, it is possible to meet Aquatic Conservation Strategy Objectives with post-analysis reserve boundaries that are quite different from the interim. Regardless of stream type, changes to Riparian Reserves must be based on scientifically sound reasoning, fully justified and documented.

Once the Riparian Reserve width is established, either based on interim widths or watershed analysis, then land management activities allowed in the Riparian Reserve will be governed by Standards and Guidelines for managing Riparian Reserves (Appendix). These Standards and Guidelines prohibit activities in Riparian Reserves that retard or prevent attainment of the Aquatic Conservation Strategy Objectives.

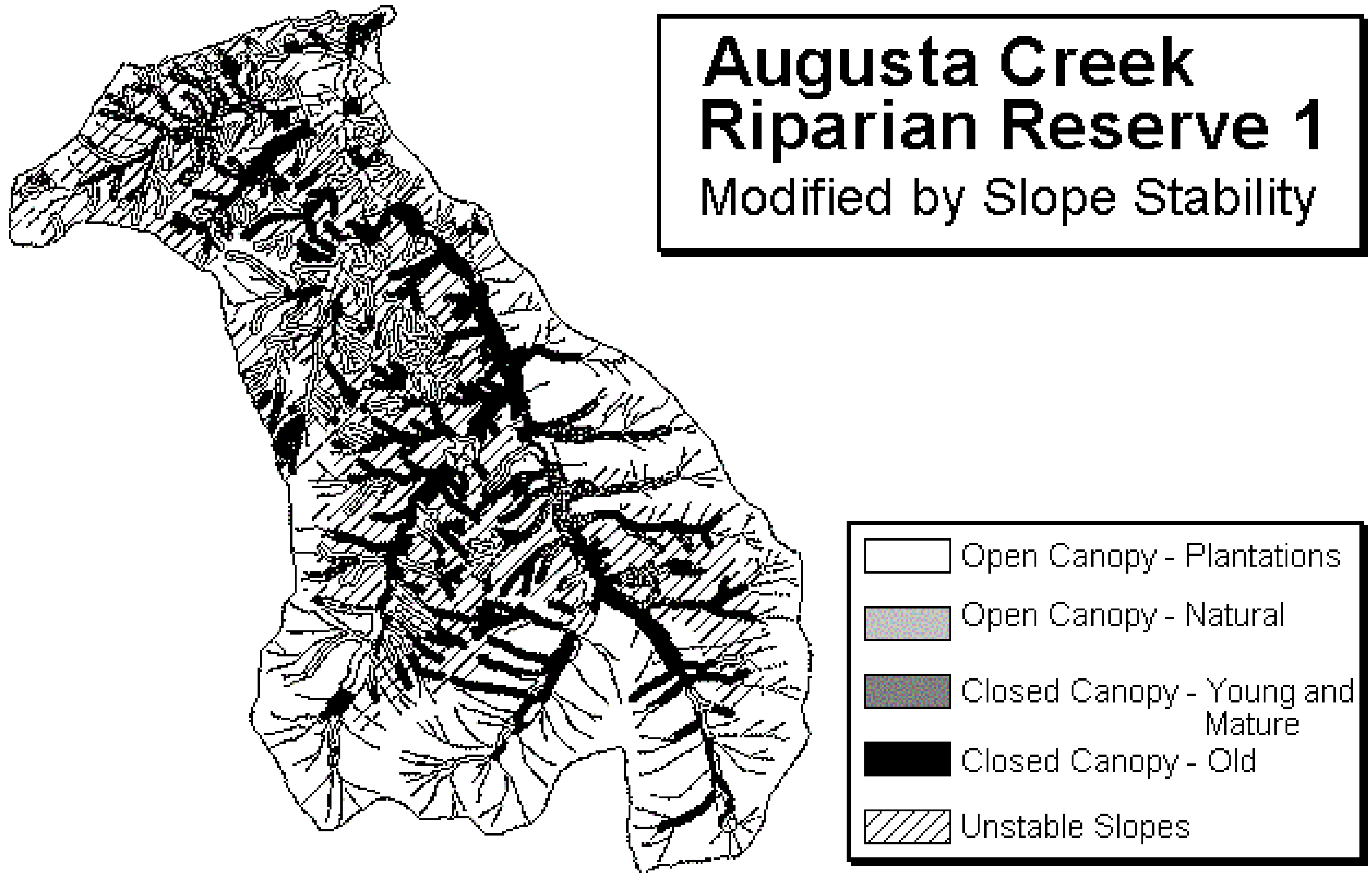

Figure 5-19. Augusta Creek watershed with Riparian Reserve 1 modified by slope stability considerations.

Key Watersheds

Refugia, or designated areas providing high quality habitat, either currently or in the future, are a cornerstone of most species conservation strategies. Although fragmented areas of suitable habitat may be important, Moyle and Sato (1991) argue that to recover aquatic species, refugia should be focused at a watershed scale. Naiman et al. (1992), Sheldon (1988) and Williams et al. (1989) noted that past attempts to recover fish populations were unsuccessful because the problem was not approached from a watershed perspective.

A system of Key Watersheds that serves as refugia is crucial for maintaining and recovering habitat for at risk stocks of anadromous salmonids and resident fish species, particularly in the short term. These refugia will include areas of good habitat as well as areas of degraded habitat. Areas presently in good condition serve as anchors for the potential recovery of depressed stocks. Those of lower quality habitat should have a high potential for restoration and will become future sources of good habitat with the implementation of a comprehensive restoration program (Component 4).

Johnson et al. (1991) identified a network of Key Watersheds located on U.S. National Forest lands throughout the range of the northern spotted owl. These watersheds contain at risk fish species and stocks and either good habitat, or if habitat is in a degraded state, have a high restoration potential (Reeves and Sedell 1992). U.S. Forest Service fish biologists have since deleted some watersheds identified by Johnson et al. (1991) and added others as new information was incorporated and an overall design developed. Watersheds on Bureau of Land Management land have also been included as Key Watersheds. Current recommendations are reflected in Figures 5-20-22. (Appendix lists all Key Watersheds.) A total of 162 Key Watersheds were designated that cover 8.7 million acres or approximately one third of the federal land within the range of the northern spotted owl (Table 5-7). Option 7 is the only option for which Key Watersheds were not designated.

The conservation strategy proposed here uses two designations for Key Watersheds: Tier 1 and Tier 2. Tier 1 Key Watersheds are specifically selected for directly contributing to conservation of habitat for at-risk anadromous salmonids, bull trout and resident fish species. The network of 139 Tier 1 Key Watersheds ensures that refugia are widely distributed across the landscape. Twenty-three Tier 2 Key Watersheds were identified. These may not contain at-risk fish stocks, but were selected as important sources of high quality water.

Because Key Watersheds maintain the best of what is left and have the highest potential for restoration, they are given special consideration. All Key Watersheds require watershed analysis prior to further resource management activity; except that in the short-term, until watershed analysis can be completed, minor activities such as those that would be Categorically Excluded under National Environmental Policy Act regulations may proceed if they are consistent with Aquatic Conservation Strategy Objectives and applying Interim Riparian Reserves and Standards and Guidelines. Key Watersheds that currently contain poor habitat are believed to have the best opportunity for successful restoration and will receive priority in any watershed restoration program.

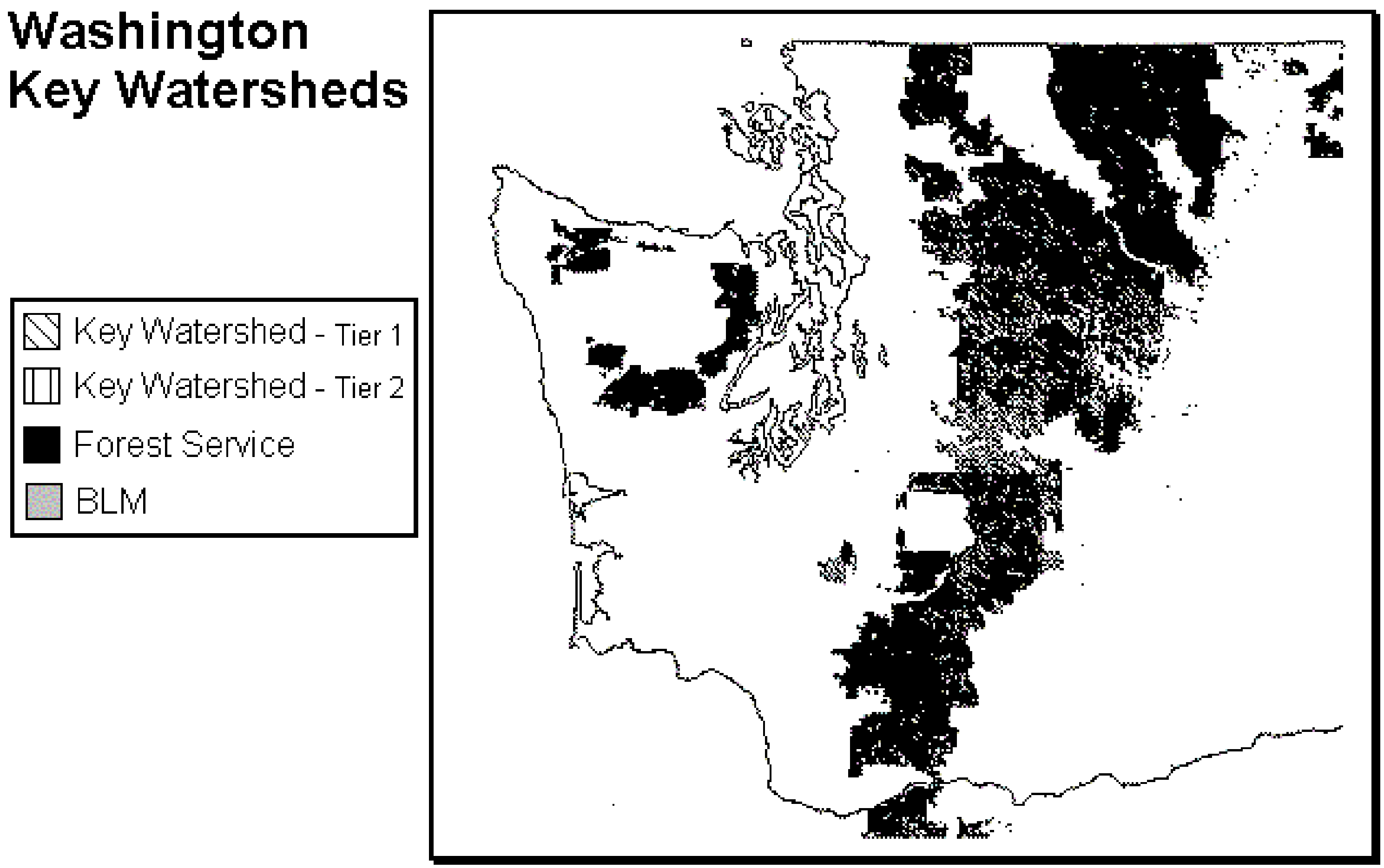

Figure 5-20. Washington Key Watersheds.

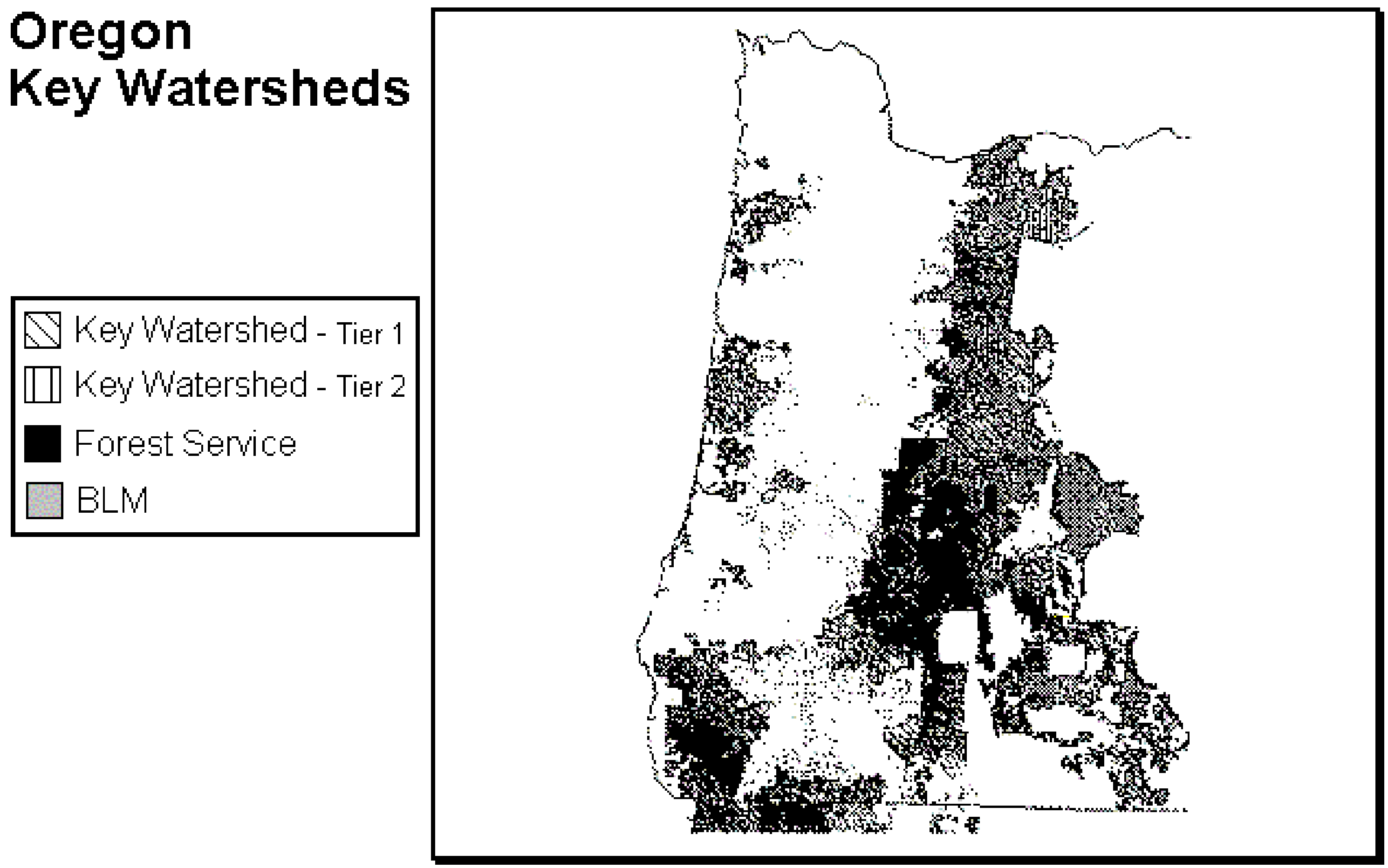

Figure 5-21. Oregon Key Watersheds.

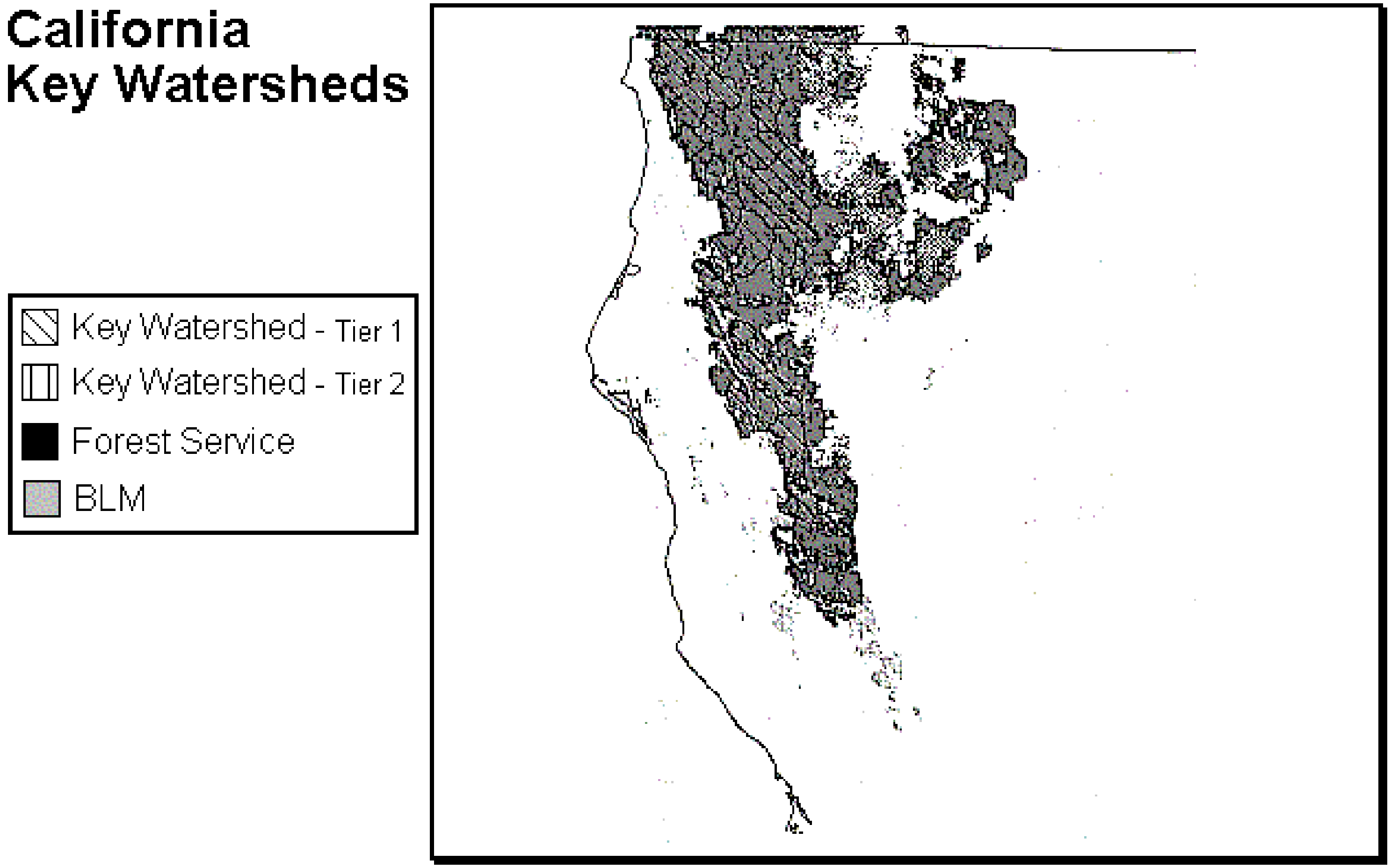

Figure 5-22. California Key Watersheds.

Area of Key Watersheds

State/Physiographic Province	Total Acres Federal Land	Tier 1 Watershed		Tier 2 Watershed	
		Total Acres	Percent of Total Fed. Land	Total Acres	Percent of Total Fed. Land
Washington					
Eastern Cascades	3,472,400	1,573,600	45	54,700	2
Western Cascades	3,721,700	1,468,300	39	219,000	6
Western Lowlands	126,300	0	0	0	0
Olympic Peninsula	1,518,800	218,900	14	48,400	3
Total	**8,839,200**	**3,260,800**	**37**	**322,100**	**4**
Oregon					
Klamath	2,106,200	573,000	27	0	0
Eastern Cascades	1,557,400	246,800	16	214,200	14
Western Cascades	4,478,200	1,269,400	28	334,600	7
Coast Range	1,396,800	346,600	25	0	0
Willamette Valley	25,600	400	2	0	0
Total	**9,564,200**	**2,436,200**	**25**	**548,800**	**6**
California					
Coast Range	388,200	56,500	15	0	0
Klamath	4,459,900	2,044,200	46	0	0
Cascades	1,009,200	0	0	0	0
Total	**5,857,300**	**2,100,700**	**36**	**0**	**0**
Three-State Total	**24,260,700**	**7,797,700**	**32**	**870,900**	**4**

Table 5-7. Area of Key Watersheds in each state and physiographic province.

Roadless areas and Key Watersheds.

Over 3 million acres of inventoried roadless areas exist within National Forests in the range of the northern spotted owl (Table 5-8). Over 50 percent of this area is in Key Watersheds, with about 48 percent contained in Tier 1 Key Watersheds (Table 5-8).

The potential disturbance to Key Watersheds from activities in roadless areas can be estimated by calculating the timber-suitable roadless acres in the general Matrix of the northern spotted owl forests. The percentage of the total roadless area which is in the Matrix varies by option from 8 percent for Option 1, to 25 percent for Option 7 (Table 5-9). The percentage of the total roadless area that is in the Matrix and is suitable for timber harvest ranges from 4 percent in Option 1 to 17 percent in Option 7 (Table 5-9). If we assume that half of the timber-suitable Matrix of roadless areas are in Key Watersheds, there are an estimated 69,000 timber suitable acres in roadless areas in Option 1 to about 256,000 timber suitable acres in roadless areas in Option 7 in Key Watersheds.

Roadless areas are often characterized by significant amounts of unstable land. For example, roadless areas in the northern half of the Wenatchee National Forest are classified as 69 percent unstable land. The southern half of the same Forest has 30 percent of its roadless areas classified as unstable. Roadless areas of the Okanogan National Forest average 54 percent unstable, the Klamath National Forest 23-28 percent unstable, the Siskiyou National Forest 16 percent unstable, the Umpqua National Forest 18 percent unstable, the Willamette National Forest between 7-20 percent unstable, and the Trinity portion of the Shasta-Trinity National Forest over 20 percent unstable. Most of these unstable areas are considered inoperable because timber harvest and road construction could cause irretrievable loses of soil productivity and other watershed values. These lands consist of erosion and landslide-prone landforms such as inner gorges, unstable portions of slump-earthflow deposits, deeply weathered and dissected weak rocks, and headwalls.

Management activities in roadless areas will increase the risk to aquatic and riparian habitat, potentially impair the capacity of Key Watersheds to function as intended, and limit the potential to achieve Aquatic Conservation Strategy objectives. Of these management activities, roads represent the greatest risk to riparian and aquatic systems; much greater than timber harvest alone. Timber harvest can increase rates of mass movement several-fold (Ice 1985; Swanson et al. 1987). Road construction increases the rates of landsliding from

30-350 fold (Sidle et al. 1985).

To protect the remaining high quality habitats, no new roads will be constructed in roadless areas in Key Watersheds under all options except Option 7 and 8 (Chapter 3). We also recommend that there be a reduction in existing road mileage within Key Watersheds. If sufficient funding does not become available for this reduction, we recommend that there shall be at least be no net increase in road mileage in Key Watersheds. That is, if a mile of new road is constructed, at least 1 mile of road shall be removed, with priority for removing roads that pose the greatest risks to riparian and aquatic ecosystems. Watershed analysis must be conducted in all non-Key Watersheds that contain roadless area before any land management activities can occur within the roadless area.

Roadless Acreage in Key Watersheds

	Forests	Roadless Acres: Within Tier 1 Key Watersheds	Within Tier 2 Key Watersheds	Outside Key Watersheds	Total Roadless
Region 6	Gifford Pinchot	53,436	31,968	124,503	209,907
	Mt. Baker-Snoqualimie	214,879	0	169,654	384,533
	Okanogan	128,834	0	142,507	271,341
	Olympic	45,015	3,869	43,200	92,084
	Wenatchee	273,214	0	257,041	530,255
	Deschutes	10,351	13,987	75,232	99,570
	Mt. Hood	47,542	24,783	63,351	135,676
	Rogue River	15,567	0	58,530	74,097
	Siskiyou	143,307	0	136,345	279,652
	Siuslaw	22,056	0	3,435	25,491
	Umpqua	48,932	0	48,336	97,268
	Willamette	41,928	10,461	90,945	143,334
	Winema	1,615	1,934	17,342	20,891
Region 5	Klamath	154,804	0	99,096	253,900
	Mendocino	10,869	0	33,399	44,268
	Trinity [a]	75,022	0	87,511	162,533
	Six Rivers	157,009	0	37,226	194,235
Total		**1,444,380**	**87,0002**	**1,487,653**	**3,019,035**
Percent of Total		**48%**	**3%**	**49%**	

[a] Figures do not include the Shasta portion of the Shasta-Trinity National Forest.

Table 5-8. Roadless acreage in Key Watersheds on National Forests within the range of the northern spotted owl.

Roadless Area in the Matrix
(Washington, Oregon and California)

	Matrix[a]		Matrix			
			Timber suitable within Long rotation Areas[b]		Timber Suitable (Includes Long Rotation Areas)	
Option	Acres	As % of Total Roadless Acres	Acres	As % of Total Roadless Acres	Acres	As % of Total Roadless Acres
1	247,880	8%	140,206	5%	140,206	5%
2	394,649	13%	115,775	4%	258,872	9%
3	497,532[c]	16%	-	-	354,834	12%
4	460,182	15%	-	-	308,939	10%
5	618,055	20%	-	-	415,156	14%
6	511,489	17%	147,422	5%	346,206	11%
7	753,696	25%	-	-	511,859	17%
8	511,489	17%	-	-	346,206	11%
9	685,323[d]	23%	-	-	454,955	15%

a - Does not include the Shasta half og the Shasta-Trinity National Forest.

b - Suitable is defined as physically suitable for timber harvest outside of Late-Successional Reserves, and Congressionally and Administratively Withdrawn Areas. We did not subtract Riparian Reserve acreage from these matrix numbers.

c - Includes roadless area in Managed Reserves.

d - Includes roadless area in Adaptive Management Areas.

Table 5-9. Roadless area in the Matrix in Washington, Oregon and California within the northern spotted owl range.

Watershed Analysis

Watershed analysis and its role in protecting aquatic habitat.

In planning for ecosystem management and establishing Riparian Reserves to protect and restore riparian and aquatic habitat, the overall watershed condition and the suite of processes operating there need to be considered. Watershed condition includes more than just the state of the channel and riparian zone. It also includes the condition of the uplands, distribution and type of seral classes of vegetation, land use history, effects of previous natural and land-use related disturbances, and distribution and abundance of species and populations throughout the watershed. These factors strongly influence the structure and functioning of aquatic and riparian habitat (Naiman et al. 1992). Effective protection strategies for riparian and aquatic habitat on federal lands must accommodate the wide variability in landscape conditions present across the Pacific Northwest. Watershed analysis plays a key role in the Aquatic Conservation Strategy, ensuring that aquatic system protection is fitted to specific landscapes.

Watershed analysis is a systematic procedure for characterizing watershed and ecological processes to meet specific management and social objectives. This information then may guide management prescriptions, including setting and refining boundaries of riparian and other reserves, developing restoration strategies and priorities, and revealing the most useful indicators for monitoring environmental changes. Watershed analysis is a stratum of ecosystem planning applied to watersheds of approximately 20-200 square miles (Figure 5-23). It is a key component in watershed planning, a process for melding social expectations with the biophysical capabilities of specific landscapes. Fully implementing ecosystem planning will require many iterations of experimentation and learning, and we cannot yet foresee in detail how organizations and institutions will evolve to accomplish it. But because of the critical role of watershed analysis in providing for aquatic and riparian habitat protection, we focus here on the role watershed analysis plays in implementing the Aquatic Conservation Strategy.

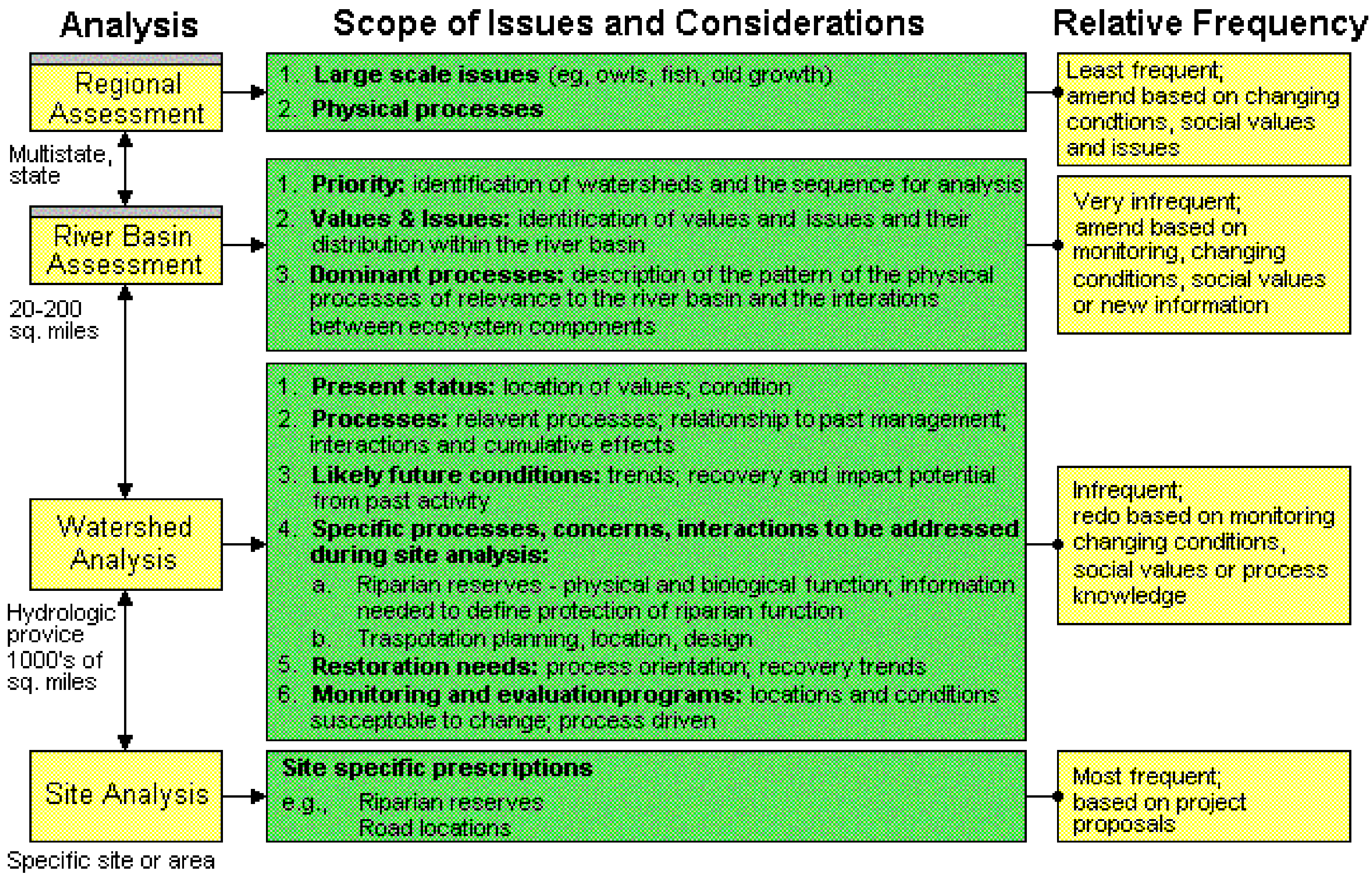

Figure 5-23. Context for Watershed Analysis.

Description of watershed analysis.

In brief, watershed analysis is a set of technically rigorous and defensible procedures designed to provide information on what processes are active within a watershed, how those processes are distributed in time and space, what the current upland and riparian conditions of the watershed are, and how all of these factors influence riparian habitat and other beneficial uses. The analysis is conducted by an interdisciplinary team consisting of geomorphologists, hydrologists, soil scientists, biologists and other specialists as needed. Information used in this analysis includes: maps of topography, stream networks, soils, vegetation, geology; sequential aerial photographs; field inventories and surveys, including landslide, channel, aquatic habitat, and riparian condition inventories; census data on species presence and abundance; disturbance and land use history; and other historical data (e.g., streamflow records, old channel surveys). A more thorough discussion on watershed analysis can be found in this Appendix.

Watershed analysis is organized as a set of modules that examine biotic and abiotic processes influencing aquatic habitat and species abundance (i.e., landslides, surface erosion, peak and low streamflows, stream temperatures, road network effects, woody debris dynamics, channel processes, fire, limiting factor analysis for key species, and so on). Results from these modules are integrated into a description of current upland, riparian, and channel conditions, maps of location, frequency, and magnitude of key processes, and location and abundance of key species. This information, in turn, is used at the site level, to set appropriate boundaries of Riparian Reserves, plan land-use activities compatible with disturbance patterns, design road transportation networks that pose minimal risk, identify what and where restoration activities will be most effective, and establish specific parameters and activities to be monitored.

While watershed analysis can provide essential information for designing land-use activities over the entire watershed, it will also highlight uncertainties in knowledge or understanding that need to be addressed. More detailed site-specific project-level analysis is conducted to provide the information and designs needed for specific projects (e.g., road siting or timber sale layout) so that riparian and aquatic habitats are protected.

Describing the full watershed analysis procedure is beyond the scope of this report. A technical team consisting of physical scientists and biologists from the U.S. Forest Service, Bureau of Land Management, and universities are writing a comprehensive handbook to set protocols and direct watershed analysis activities. The first draft of this handbook is scheduled to be available by July 15, 1993 (Appendix).

Relation to other approaches.

Numerous procedures have been used over the past several decades to address watershed environmental concerns on private and federal lands. Some recent procedures developed for federal lands attempt to address cumulative effects; examples include the Equivalent Clearcut Area, Equivalent Roaded Area, U.S. Forest Service Region 1 and Region 4 Sediment-Fish Model, California Department of Forestry Questionnaire, and Aggregated Recovery Percentage. Most of these methods rely on relatively simple indices related to the area of lands impacted by roads, clearcuts, or other land use activities. A somewhat more sophisticated approach was recently developed to evaluate cumulative risk of multiple projects in the Snake River basin (U.S. Forest Service 1991). This method used a broader set of hillslope and channel indices along with intensity of past practices to evaluate watershed condition and estimate effects from future activities. This analysis ultimately rested, however, on a set of matrices that combined indices qualitatively to produce a final assessment of the risk of future impacts.

These methods all suffer from a similar set of problems: unclear logic used in weighting or combining individual elements, reliance on simple indices to explain complex phenomena, and assumptions of direct or linear relations between land use intensity and watershed response. They typically do not consider how key processes are distributed over watersheds within a given landscape and, in many cases, do not distinguish between physiographic provinces, which can vary widely in the importance of individual processes. Furthermore, most of these approaches lack any method to validate their assumptions or results.

Watershed analysis is emerging as a new standard for assessing watershed condition and land use impacts. The process described here builds on newer, more comprehensive approaches, including the Water Resources Evaluation of Nonpoint Silvicultural Sources program, the watershed analysis procedure developed by the Washington State Timber, Fish and Wildlife program, and the cumulative effects methods being developed by the National Council on Air and Stream Improvement. Analysis modules in watershed analysis are patterned after the first two approaches because a modular approach allows flexibility in selecting methods appropriate to a particular watershed and facilitates modification of specific techniques as improved methods become available. Unique aspects of the watershed analysis procedure described here include explicit consideration of biological as well as physical processes, and the joint consideration of upland and riparian zones.

Watershed analysis is a relatively new concept and has not yet been adopted on U.S. Forest Service or Bureau of Land Management. We are aware of U.S. Forest Service examples of watershed analysis that focus on physical processes. The best, though unpublished, example analyzes the physical setting of the 19,000 acre Augusta Creek. This analysis was undertaken by the Blue River Ranger District and Cascade Center for Ecosystem Management on the Willamette National Forest (see Appendix). Another example is the Draft Environmental Impact Statement for the Elk River Wild and Scenic River on the Siskiyou National Forest. There are undoubtedly many other examples of projects that incorporate key elements of watershed analysis on Forest Service and Bureau of Land Management lands though perhaps under different names.

Role of watershed analysis in aquatic options.

Watershed analysis holds great promise as a means of effectively implementing ecosystem planning and management on a watershed basis. Ultimately, information gained through watershed analysis will be vital to adaptive management over broad physiographic regions. Developing the institutional capacity to absorb and respond to new information generated by watershed and other analyses represents a significant challenge for the next decades. We have indicated that watershed analysis is only required in Key Watersheds prior to land management. Ultimately however, watershed analysis should be conducted in all watersheds on federal lands as a basis for ecosystem planning and management. When current Land Management Plans are revised, information gathered through watershed analysis will, in part, be the basis of these revisions.

Watershed Restoration

Stream and riparian systems have been significantly degraded by past management actions, including selective or complete cutting of streamside forests, removal of woody debris from channels, and construction of roads that increase streamflow and sediment production. Therefore, Watershed Restoration shall be an integral part of a program to aid recovery of fish habitat, riparian habitat, and water quality. The most important elements of a restoration program are control and prevention of road-related runoff and sediment production; restoration of riparian vegetation condition; and restoration of in-stream habitat complexity. Other restoration opportunities exist, such as meadow and wetland restoration and mine reclamation, and these may be quite important in some areas. Regionally however, these opportunities are much less extensive than the three listed above. A detailed discussion of Watershed Restoration is found in Appendix.

Roads

Federal lands within the range of the northern spotted owl contain approximately 110,000 miles of roads (Table 5-2). Much of this network adversely affects water quality and peak flows. The capacity of Forest Service and Bureau of Land Management to maintain roads has declined dramatically as both appropriated and traffic-generated funds for maintenance and timber-purchaser-conducted maintenance have been reduced. Without an active program to identify and correct road problems, habitat damage will continue for decades. Well-established practices to control road generated erosion and peak flows can drastically reduce risks of future habitat damage. In watersheds containing high quality habitat and limited road networks, large amounts of habitat can be secured with small expenditures to upgrade and remove roads (Harr and Nichols 1993).

Road treatments range from full decommissioning (closing and stabilizing a road to eliminate potential for storm damage and need for maintenance) to simple road upgrading, which leaves the road open. Upgrading can involve practices such as removal of earth from locations with high potential to trigger landslides, modification of road drainage systems to reduce the extent to which the road functions as an extensions of the stream network, and reconstructing stream crossings to reduce the risk and consequences of failure.

Decisions to apply a given treatment depend on the value and sensitivity of downstream uses, transportation needs, social expectations, "treatability" of the problems, costs, and other factors. Watershed analysis, including the use of sediment budgets, provides a framework for considering benefit to cost relations in a watershed context. Thus, the magnitude of regional restoration needs will be based on watershed analysis.

Riparian vegetation

Active silvicultural programs may be necessary to restore large conifers Riparian Reserves. Appropriate practices may include planting unstable and potentially unstable areas such as streamside landslides and flood terraces, thinning densely-stocked young stands to encourage development of large conifers, releasing young conifers from overtopping hardwoods, and reforesting shrub- and hardwood-dominated stands with conifers. These practices can be implemented along with silvicultural treatments in uplands areas, although the practices may differ in objective and, therefore, design.

There has never been a regionwide assessment of need or opportunity for watershed restoration through riparian silviculture. However, there are over 200,000 miles of streams on public lands in the range of the northern spotted owl, and this suggests that substantial opportunity exists for improving watershed condition through riparian silviculture. Current research provides direction for designing effective programs.

In-stream habitat structures

In-stream restoration, based on accurately interpreted physical and biological processes and deficiencies, can be an important component of an overall program for restoring fish and riparian habitat. In-stream restoration measures are inherently short term and must be accompanied by watershed-wide practices to achieve long-term restoration. Maintaining desired levels of channel habitat complexity, for example, may best be achieved in the short term with introduced structures. However, a healthy riparian forest should be the source of large woody debris to the channel in the long-term.

In-stream restoration will be accompanied by riparian and upslope restoration and not used by itself if watershed restoration is to be successful. Also, use of in-channel structures should not be viewed as a substitute for habitat protection (Reeves et al. 1991). They will not be used as mitigation for risky land-management activities and practices. Priority must be given to protecting existing good habitat.

Implementing a restoration program

The balance of efforts among these three elements of watershed restoration varies with location within a watershed and from one physiographic province to another. In-stream woody debris structures, for example, have greatest likelihood of being effective in channels with slope less than two degrees and those not dominated by large boulders. Removal of roads and full recontouring of hillslopes has been most extensively employed in the Redwood Creek area, northern California, where sediment yields are high, roads have been major sediment sources, and the management objective has been to convert tractor-yarded clearcuts to National Park land. Other measures may be more useful elsewhere in the Pacific Northwest, such as simple road decommissioning or riparian silviculture.

Restoration shall be based on watershed analysis and planning. This is essential to identify areas of greatest benefit to cost and greatest likelihood of success. Watershed analysis can also be used as a medium to develop cooperative projects involving various land owners. In many watersheds the most critical restoration needs are on private lands downstream of federal ownership.

A viable, effective program must employ all restoration components and must be long term. Inventory, analysis, the National Environmental Policy Act process, implementation, and monitoring all take time. Without adequate investment in each of these steps, restoration efforts will be ineffective -- ample evidence demonstrates this point. Funding and management commitment to a 10-year program is essential.

Implementation of the Aquatic Conservation Strategy

Ecosystem planning needs to be conducted at four spatial scales: regional, province/river-basin, watershed, and site. The *region* for the purposes of this report is the Pacific Northwest, encompassing the range of the northern spotted owl. *Provinces* are areas of common geology, climate, and physiography in which technical information from one area can be widely extrapolated. Their scale is comparable to that of major river basins, such as the Klamath, Umpqua, or Willamette, or groups of small coastal watersheds with similar beneficial-use and resource-value issues. Provinces may overlap several river basins, and river basins may contain parts of several physiographic provinces. *Watersheds* are sub-basins of 20-200 square miles and are the scale at which Watershed Analyses are conducted. *Sites* are areas of variable size but typically range from tens to hundreds of acres, where specific activities, such as timber harvest, watershed restoration, silvicultural treatments, road construction, or other management activities, take place. Sites will typically require project-level analysis for planning ecologically appropriate resource management activities.

The four key components of the Aquatic Conservation Strategy (Riparian Reserves, Key Watersheds, watershed analysis, and Watershed Restoration) should be addressed in the four spatial scales of implementation. Key Watersheds and Riparian Reserves will be identified commensurate with the option chosen to implement the regional strategy. Watershed Analyses are the building blocks for provincial conservation strategies and for planning activities at the watershed scale. Provincial plans will begin to identify restoration goals and priorities. Watershed Analyses will define restoration priorities and strategies and enable design of appropriate restoration activities.

Interagency teams will be convened to guide implementation of the regional strategy and to conduct analyses and prepare plans for physiographic provinces and watersheds. These teams would include the land management agencies (U.S. Forest Service and Bureau of Land Management) and the resource regulatory agencies (National Marine Fisheries Service, U.S. Fish and Wildlife Service, and the U.S. Environmental Protection Agency).

For each of the options, the Forest Ecosystem Management Assessment Team evaluated the ability of federal lands to provide sufficient quality, distribution, and abundance to allow populations of fish species to stabilize, well distributed across forest lands. In considering the effects of any federal land management option on anadromous fish, two key points are important: (1) there may be other factors, such as over harvest, disease, hatchery practices, and other habitat impacts such as hydropower and irrigation developments that have caused and continue to affect the declines of anadromous salmonid populations; and (2) a plan for managing federal lands will not necessarily fix problems on nonfederal land, and anadromous fish are, in many cases, adversely impacted by nonfederal actions. For these reasons, it is not possible to determine whether this regional level conservation strategy would preclude listing of fish species under the Endangered Species Act.

If fish species listed under the Endangered Species Act are present within the northern spotted owl's range, the land management agencies will need to consult on the effects of their actions pursuant to Section 7 of the Act in this multiscale context. Consultation may be needed at three levels: (1) on the final regionwide plan; (2) then during the implementation phase, on the provincial, watershed, or other management plans (that step down the regionwide plan): and (3) on individual actions. These consultations will likely be necessary because there will be insufficient detail in the regionwide plan to adequately assess impacts of actions at the provincial, watershed, or individual level. During all phases, informal consultation can be provided, as necessary.

Role of Nonfederal Lands

A critical implementation aspect is that ecosystem management is most successful when all federal and nonfederal landowners and agencies that affect a watershed participate. Federal landowners currently have sufficient incentives (i.e., statutes, regulations, and litigation) to manage lands for viable fish habitat and fish populations. However, the incentives for nonfederal landowners and regulators currently are lacking. Some mechanisms identified by the Federal Ecosystem Management Assessment Team for encouraging ecosystem management on nonfederal ownership of include physiographic province and watershed analyses and planning and implementation of the Endangered Species Act, if listed species are present.

Watersheds provide a rational and effective spatial scale for citizens to participate in natural resource decision making. Watersheds encompass a wide diversity of ownerships, issues, and viewpoints. Because much of the historical habitat for anadromous fish species is on nonfederal lands, planning discussions for a watershed should include all landowners in the watershed (state, tribes, and private). Although provincial and watershed plans would be developed for federal lands, the provincial teams should have representation from the states and tribes in assessing related ecosystem problems and necessary actions for state and private lands in the watersheds. State and federal actions should be integrated for optimal environmental effectiveness.

The Endangered Species Act also has several mechanisms for encouraging and requiring nonfederal participation in ecosystem management. The provincial planning process could produce such agreements or understandings as prelisting conservation agreements between the U.S. Fish and Wildlife Service or National Marine Fisheries Service and federal or nonfederal land managers; anticipated timber harvest schedules on nonfederal lands; and Endangered Species Act Section 10 habitat conservation plans. The provincial and watershed planning process is also intended to facilitate working with the states on Section 4(d) rules for improved clarity and certainty under the "take" provisions of the Endangered Species Act.

If Section 7 consultations are necessary for listed species, the effects of the federal action will be evaluated with the cumulative effects of nonfederal actions to determine whether there may be a jeopardy or destruction or adverse modification of critical habitat action. The Endangered Species Act defines cumulative effects as those of future state or private activities not involving federal activities that are reasonably certain to occur within the action area of the federal action subject to consultation. It follows that the degree to which future nonfederal activities impact listed species will affect the federal land management agencies' ability to avoid jeopardy consultations. Thus, there is also powerful incentive for federal land managers to work closely with nonfederal groups in ecosystem planning.

Riparian Protection on State and Private Lands

Although the Bureau of Land Management and the U.S. Forest Service will likely invest heavily in protecting the remaining aquatic and riparian habitat, the federal government cannot be solely responsible for ensuring the viability of migratory fish species. Unless state and private lands receive protection sufficient to prevent further degradation and to promote habitat recovery, benefits derived from federal efforts will be diminished.

Best management practices are tactics used to protect water quality and the beneficial uses of water including fish and water-dependent wildlife on state and private lands. Oregon and Washington both have forest practice acts and regulations that include Best Management Practices intended to protect aquatic riparian habitats. However, California Forest Practices Rules have not yet been certified as Best Management Practices under the Clean Water Act.

Three scenarios are presented and examined in this report for managing riparian areas on federal lands. See the descriptions of plan options for detailed discussion of Riparian Reserves and applicable Standards and Guidelines (Appendix). All three scenarios are more restrictive of management activities and thus, are more protective of water quality, fish habitat, and riparian areas than state requirements.

Two major differences between current state requirements and proposed federal requirements are apparent. First, the states allow significant harvest within the riparian management areas. Second, the width of the protective buffers are smaller in state programs. This is particularly true for intermittent and smaller perennial streams. None of the states require protection of riparian areas for intermittent streams. The proposed federal Aquatic Conservation Strategy provides protection through Riparian Reserves that are sufficient to maintain important functions of large wood delivery, leaf and particulate organic matter input, shade, riparian microclimate, slope stability, water quality and riparian wildlife habitat (Figure 5-12 and Figure 5-13). See this Appendix for detailed description of state forest practices.

Timber harvest disturbance on nonfederal lands will probably continue at 1980's levels (Figure 2-18). Current state forest practice rules do not adequately protect ecological effectiveness nor provide any margin for error to accommodate natural disturbances or uncertainties in knowledge. Thus, reliance on federal lands to supply habitat for aquatic species and fish stocks will increase. Federal lands currently provide most of the highest quality water and fish habitat within the range of the northern spotted owl. Habitat conditions on private and state lands are inadequate to provide well distributed, stabilized populations of salmonids. If measures are not taken to improve management practices on state and private lands, options for federal land management may become more limited. To succeed, the federal Aquatic Conservation Strategy should be accompanied by companion strategies for nonfederal lands. Although any aquatic conservation strategy employed on state and private lands should have the same components (Riparian Reserves, Key Watersheds, watershed analysis, and Restoration) as the federal strategy, these is not necessary that they be identically administered.

Monitoring

General considerations. Watershed analysis will provide the decision framework for a variety of planned ecosystem management actions within watersheds. Specific actions may include habitat restoration, correction of sedimentation problems, road management, timber harvesting, development of a recreation facility or any of a multitude of activities. Monitoring will be an essential component accompanying these management actions and will be guided by the watershed analysis.

General objectives of monitoring will be to (1) determine if Best Management Practices have been implemented (2) determine the effectiveness of management practices at multiple scales, ranging from individual sites to watersheds and (3) validate whether ecosystem functions and processes have been maintained as predicted. In addition, monitoring will provide feedback to fuel the adaptive management strategy.

Specific monitoring objectives will derive from results of the watershed analysis and be tailored to each watershed. Specific locations of unstable and potentially unstable areas, roads, and harvest activities will be identified. In addition, the spatial relationship of potentially unstable areas and management actions to sensitive habitats such as wetlands will be determined. This information provides a basis for targeting watershed monitoring activities to assess outcomes associated with risks and uncertainties identified during watershed analyses.

Under natural conditions, river and stream habitats on federal forest lands exhibit an extremely wide diversity of conditions depending on past disturbance, topography, geomorphology, climate and other factors. Consequently, monitoring of riparian areas must be dispersed among the various landscapes rather than concentrated at a few sites and then extrapolated to the entire forest (Gregory 1990). Logistic and financial constraints require a stratified monitoring program that includes:

Post-project site review.
Reference sub-drainages.
Basin monitoring.
Water quality network.
Landscape integration of monitoring data.

A stratified monitoring program examines watersheds at several spatial and temporal scales. Information is provided on hillslope, floodplain, and channel functions, water quality, fish and wildlife habitat and populations, and vegetation diversity and dynamics.

Water quality parameters. Parameters selected for monitoring depend on the activities planned for a given watershed relative to forestry practices. Two of the most important activities related to water quality are impacts of timber harvest and road related operations. Details on the selection of water quality parameters and interactions can be found in MacDonald et al. (1991). In addition to chemical and physical parameters, biological criteria may be appropriate to monitor using techniques such as Rapid Bioassessment Protocols for macroinvertebrates (Plafkin et al. 1989) or the index of biotic integrity for fish diversity (Karr, 1981; Ohio EPA, 1988).

Long term monitoring in reference watersheds. Long-term systematic monitoring in selected watersheds will be necessary to provide reference points for effectiveness and validation monitoring. Reference watersheds should represent a range of forest and stream conditions which have been exposed to natural and induced disturbance. Requirements for reference evaluation areas are discussed in Gregory and Ashkenas (1990). Reference watersheds, sub-basins, and sites will be selected as part of the overall adaptive management strategy proposed for implementing this plan.

Study plans will be developed in cooperation with a cross section of team members from the Provincial Teams and local interdisciplinary teams. Long-term data sets from reference watersheds will provide an essential basis for adaptive management and a gauge by which to assess trends in stream condition.

Specific monitoring plans must be tailored for each watershed. Significant differences in type and intensity of monitoring will occur based on watershed characteristics and management actions. For example, carefully targeted restoration activities may only require effectiveness monitoring of single activities, whereas watershed scale restoration would be accompanied by extensive riparian and in-stream monitoring. Specific monitoring design can best be accomplished by the local interdisciplinary teams working in cooperation with state programs. Pooling the monitoring resources of federal and state agencies is a necessity to provide interagency consistency and to increase available resources.

Monitoring will be conducted and results will be documented, analyzed and reported by the agency responsible for land management in any particular watershed. Reports will be reviewed by local interdisciplinary teams. In addition, water resource regulatory agencies may review results to determine compliance with appropriate standards and Provincial Teams should assess results against overall basin strategies. A cross-section of team members that includes participants from states and regulatory agencies should assess monitoring results and recommend changes in Best Management Practices or the mechanisms for Best Management Practice implementation.

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Effects of Options on Aquatic Ecosystems

We assessed the likelihood of attaining a set of outcomes for habitat of individual races/species/groups of fish on federal lands for each option. This outcome-based scale was developed to express the range of possible trends and future habitat conditions on federal land (table IV-7). Each of four outcomes, labeled A through D, describes a biological condition that is observable and mutually exclusive of the other three outcomes. In *outcome* A, habitat is of sufficient quality, distribution, and abundance to allow the species' population to stabilize, well distributed across federal lands. (Note that the concept of well distributed must be based on knowledge of the species distribution, range, and life history). In *outcome B*, habitat is of sufficient quality, distribution, and abundance to allow the species' population to stabilize, but with significant gaps in the historic species distribution on federal land. These gaps cause some limitation in interactions among local populations. (Note that the significance of gaps must be judged relative to the species distribution, range, and life history, and the concept of metapopulations). In *outcome* C, habitat only allows continued species existence in refugia, with strong limitations on interactions among local populations. In *outcome D*, habitat conditions result in species extirpation from federal land.

The panelists were asked to assign 100 likelihood votes' (or points) across the four outcomes in the scale. A panelist could express complete certainty in a single outcome for a species/option combination by allocating all 100 points to a single outcome. The panelist could express complete uncertainty by assigning *25* votes to each of the outcomes, indicating that each outcome was equally likely. Greater detail on outcomes and rating scales are described in chapter IV.

We compared options by assessing the likelihood of each to achieve outcome A. However, there is no single such level that represents a viable ecosystem or habitat, or a viable population for all species and circumstances. The level was chosen here as a point of comparison only; other levels -- for example, a 95 percent likelihood of achieving outcome A, or a 60 percent likelihood of Option B -- could also he chosen for comparing options. The information on likelihoods is available and is amenable for such additional comparisons.

Methods Specific to Fish

In assessing the options we considered five factors: (1) assessments for the individual races/species/groups made by the expert panel (see chapter IV for description of expert panels); (2) amount of Riparian Reserves and type and level of land-management activity allowed within in them; (3) extent of other reserves (e.g, Congressionally Withdrawn Areas, Late-Successional Reserves) and type and level of land management allowed within them; (4) presence of a watershed restoration program (as described previously); and (5) prescriptions for management of Matrix lands.

We considered the first three factors equally in determining the score for an outcome under each option. We believed that these components most strongly influence the preservation, maintenance, and restoration of aquatic ecosystems and habitat.

The expert panel also assessed the likelihood of attaining the set of outcomes for habitat of the individual races/species/groups of fish for each option. The panel was presented with descriptions of the outcomes and options. They were also asked to partition out the effects of factors such as habitat conditions on nonfederal lands, land ownership patterns, and oceanic conditions. Each panelist made their own assessment. Like the Terrestrial Ecosystem Assessment (chapter IV), the expert panel was only asked to assess Options 1, 3, 4, 5, 7, 8, and 9. We then used this information as part of our assessment of the options. They were not asked to consider Options 2, 6 and 10. Assessment of these options was done by the Aquatic Ecosystem Group.

Ecological functions and processes required for the creation and maintenance of fish habitat were provided by Riparian Reserves. The greater the amount of Riparian Reserves, the more it contributed to the ranking. Riparian Reserves 1 (see previous descriptions) provide the fullest suite of functions and processes (see figs. V-12 - V-14) and thus contributed to higher ratings than did Riparian Reserves 2 and 3. Area of Riparian Reserves under each option is shown in table V-4.

In our assessments, we also assumed that the boundaries of Riparian Reserves, particularly in intermittent streams, could change following watershed analysis. This does not imply, however, that watershed analysis may always reduce the boundaries of Riparian Reserves in intermittent streams; it is expected that actual boundaries may vary considerably among watersheds. We assumed that the boundaries in other stream types would not vary appreciably. In all cases we assumed final Riparian Reserves would provide the necessary range of ecological functions and processes that create and maintain good fish habitat.

We believed that Reserves such as Congressionally Withdrawn Areas and LateSuccessional Reserves construed two benefits to aquatic habitat and ecosystems. These are areas where land-management activity would be limited. They would thus provide a high level of protection for all streams within them. This would in turn provide the ecological functions and processes necessary for the creation and maintenance of fish habitat. Additionally, streams in Reserves could serve as cores of good habitat in a

landscape with large areas of poor habitat. They would be refugia and population centers for recolonization as degraded areas recovered in the future. This would be particularly important for locally distributed fish species and races. The greater the amount of these reserves the greater would be the level of protection for existing aquatic ecosystems and habitat.

The area of reserved land in key watersheds is very important for fish habitat protection. Tier 1 Key Watersheds have different percentages of reserves within them depending on the option and the state (see appendix V-H for greater detail). In the state of Washington the percentage of Tier 1 Key Watersheds in reserves excluding Riparian Reserves ranges from 8 1-87 percent across all options. In Oregon the range is wider from 55 percent of Key Watersheds in a reserve status in option 7 to 84 percent in Option 1. The remaining options cluster between 66-70 percent reserves in Oregon Tier 1 Key Watersheds. Reserves in California Tier 1 Key Watersheds varied from 69 percent in Option 7 to 88 percent in Option 1. Reserves in Tier 1 Key Watersheds across the forests of the northern spotted owl and ranged from 70 percent in option 7 to 86 percent in Option 1, with most options clustering between 74-77 percent. The percent of Tier 1 Key Watersheds in the Matrix ranged from 8 percent in Option 1 to 28 percent in Option 7. Options 2-5 and 9 ranged between 12-15 percent Matrix in these Key Watersheds (see appendix V-H for greater detail).

Tier 2 Key Watersheds are found primarily in the Cascades of Washington and Oregon. Watersheds in these areas tend to be more stable or have less risk from landslides. California has no Tier 2 Key Watersheds. In Washington the percent of Tier 2 Key Watersheds in reserve status ranges between 60-84. Option 9 has 60 percent of Tier 2 Key Watersheds in a reserve status and 18 percent in an Adaptive Management Area status. In Oregon, Option 1 provided the greatest percentages of reserves to Tier 2 Key Watersheds at 80 percent. Tier 2 Key Watersheds in option 7 had 52 percent in a reserve status. The percent area of Tier 2 Key X[T]atersheds in the Matrix varied from 13 in Option 1 to 40 in Option 7. For Washington and Oregon combined Option 1 had 82 percent of Tier 2 Key Watersheds in reserve status and Options 7 and 9 had 62 percent. (See appendix V-H for greater detail.)

The other factors, watershed restoration and Matrix management prescriptions, were given less weight. However, we and the expert panel acknowledged that a comprehensive watershecL restoration program was necessary for restoring aquatic habitat particularly in the short-term. Among options, Matrix management prescriptions were weighted according to the area of the Matrix and required management guidelines (e.g., rotation length, green tree retention). The greater the green tree retention requirements and/or the longer the rotation, the greater the contribution to the likelihood rating.

The expert panel was presented with 19 races/species/groups of fish to consider. A total of 29 species were contained in these groupings (table V-ic). Of these species, five were then being considered for status under the Endangered Species Act, and one other was identified in the professional literature as in need of special management consideration because of low or declining populations.

Members of the expert panel decided to fully evaluate only seven of the 19 races~species/groups presented originally. Reasons for not considering the 12 races/species/groups were: (1) insufficient information on the ecology to make a valid assessment; (2) limited distribution of the species/group/races on federal lands within the range of the northern spotted owl; and (3) judging from available information, possible habitat alterations that may occur as result of land-management practices on federal lands would have no or negligible effect on the habitat of the species/group/race. The panel commented on what they believed may be the potential outcome of an option on some races/species/groups for which they had limited knowledge. We evaluated only the seven races/species/groups fully considered by the expert panel.

All fish in the species/groups for which assessments were made are salmonids. Most are distributed in streams of late-successional forests on federal lands throughout the range of the northern spotted owl. They use a wide size range of streams, from larger streams by chinook salmon to small, headwater streams by resident cutthroat and rainbow trout. All require clean gravels to reproduce successfully, cool water (generally less than 68oF), and diverse and complex habitat. Bjornn and Reiser (1991) discuss specific requirements of the individual species. As indicated previously in the chapter, habitat features for these fish are susceptible to impacts from land-management practices, and so these fish are reasonable indicators of ecosystem health.

Table V-10. Fish races/species/groups presented to but not considered by expert panel.

	Reason not considered		
Fish Species	Insufficient information on ecology	Limited distribution on federal lands	Possible effects from land-management practices on federal lands negligible
Pacific lamprey	X		
Sockeye salmon [a]		X	
Pink salmon [a]		X	
Chum salmon [a]		X	
Redband trout			
White River, OR	X		
McCloud River, CA [b]	X		
Jenny Creek, OR	X		
Mountain whitefish	X		

White River, OR	X		
McCloud River, CA [b]	X		
Jenny Creek, OR	X		
Mountain whitefish	X		
Dolly varden		X	
Umpqua squawfish		X	X
Umpqua chub	X	X	
Oregon chub [b]	X	X	
Olympic mudminnow [b]	X		
Salish sucker [c]	X		
Jenny Creek sucker [b]	X		
Reticulate sculpin	X		
Paiute sculpin	X		
Riffle sculpin	X		
Shorthead sculpin	X		
Torrent sculpin	X		
Mottled sculpin	X		
Coastrange sculpin	X		
Longnose dace	X		
Millicoma dace	X		

a Some stocks within region of the northern spotted owl listed by Nehlsen et al. (1991) as in need of special management considerations because of low or declining populations.
b Candidate for listing under Federal Endangered Species Act.
c Listed by Williams et al. (1991) as in need of special management considerations because of low or declining populations.

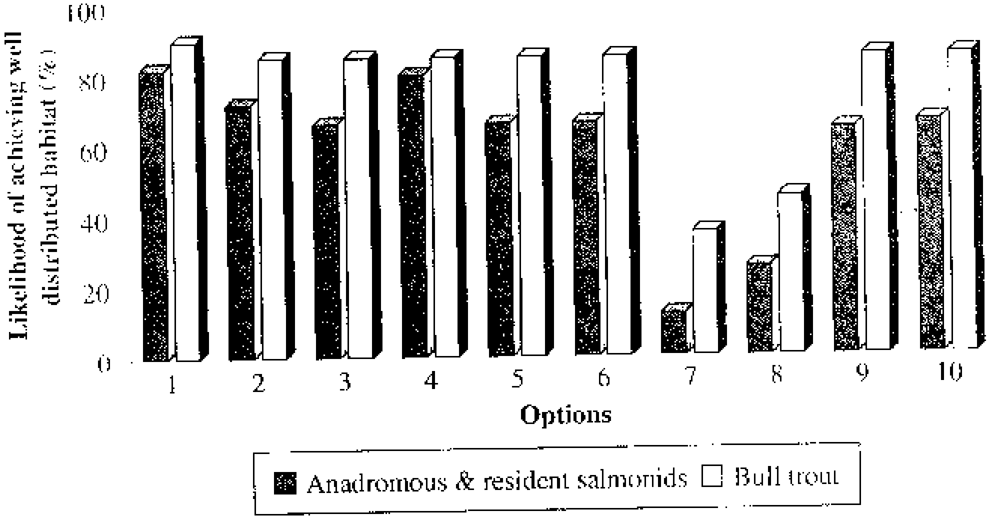


Figure V-24. Assessment of the percent likelihood of achieving aquatic habitat of sufficient quality, distribution and abundance to allow fish species to stabilize well distributed across federal lands. The salmonids grouping is an average of six separate assessments. The range around the mean for each option was within plus or minus 5 percent.

RESULTS

Our assessments of the options are shown in table V-il. Options 1 and 4 had the highest likelihood of attaining outcome A (i.e., habitat will be widely distributed on federal lands throughout the range of the northern spotted owl); the likelihood was 80 percent or higher for all race/species/groups (fig. V-24). The relatively high likelihood for these options was because of the large amount of area in reserves (table V-4) and the Riparian Reserve 1 strategy on all federal lands within the range of the northern spotted owl.

Options 2, 3, 5, 6, 9, and 10 generally had a 60-70 percent likelihood of attaining outcome A for all races/species/groups. These options had a smaller likelihood of attaining outcome A than Options 1 and 4 because of a combination of less area in Reserves and the Riparian Reserve 2 scenario, which has Interim Riparian Reserves of one-half of a site potential tree in intermittent streams outside Key Watersheds.

The likelihood of outcome A for bull trout was 85 percent in each of Options 2, 3, 4, 5, 6, 9, and 10. As far as we could discern from available distributidn maps, the vast majority of, if not all, bull trout habitat on federal land within the range of the northern spotted owl was contained within Key Watersheds. The high level of protection provided by the Riparian Reserves and the extent of other reserves in Key Watersheds resulted in a high level of protection to bull trout habitat.

Resident rainbow and cutthroat trout had the lowest likelihood of attaining outcome A, 60 percent, for options 2, 3, 5, 6, 9, and 10. These fish inhabit small, headwater streams. We believed that the prescribed Riparian Reserve 2 boundaries outside Key Watersheds reduced the level of protection for the habitat of these fish. It is likely that habitats of other fish found in these streams, such as many of the sculpins and longnose dace would be similarly affected by these options.

The likelihood of achieving outcome A for fish habitat is lower for Options 2, 3, 5, 6, 9, and 10 than for Options 1 and 4. However, we think all options except Option 7 and 8 will reverse the trend of degradation and begin recovery of aquatic ecosystems and habitat on federal lands within the range of the northern spotted owl. Even if changes in land management practices and comprehensive restoration are initiated, it is possible that no option will completely recover all degraded aquatic systems within the next 100 years. The likelihood of attaining a functioning late-successional/old growth ecosystem in the next 100 years is reduced because some characteristics of these terrestrial ecosystems will not be obtained for at least 200 years (see chapter IV). Similarly, we expect that degraded aquatic ecosystems will not be fully functional in 100 years. Faster recovery rates are probable for aquatic ecosystems under Options 1 and 4 than other options. Option 1 and 4 would reduce disturbance across the landscape due to application of a larger Late-Successional Reserve network and use of Riparian Reserve 1 scenario, that requires wider interim Riparian Reserves for intermittent streams in non- Key watersheds than in other scenarios.

Options 7 and 8 had the lowest likelihoods of attaining outcome A for all races/species/groups (table V-il). The likelihood of attaining outcome A for Option 7 was from 10-15 percent, the exception being bull trout, which was 35 percent. Option 7 was ranked low primarily because of the low amount of riparian areas and the amount of activity that was allowed within them in Bureau of Land Management land management plans and in many forest plans. It should be noted that these assessments reflect assessments for forest plans as a group and not for individual plans, which varied tremendously. During the life of the plan, many individual plans stated that fish habitat would continue to degrade due to management activities, other plans provide nondegraded conditions as well as watershed restoration.

Table V-11. Projected future likelihoods of habitat outcomes for selected fish races/species/groups under land management options. Likelihood values are expressed as percentages that total 100 for each option.

Fish race/species/group	1	2	3	4	5	6	7	8	9	10
Coho Salmon										
Outcome A	80	70	65	80	65	65	10	20	65	65
Outcome B	15	20	25	15	25	25	20	25	20	25
Outcome C	5	10	10	5	10	10	50	35	15	10
Outcome D	0	0	0	0	0	0	20	10	0	0
Fall Chinook Salmon										
Outcome A	85	75	70	80	70	70	15	30	65	70
Outcome B	15	20	25	15	20	25	25	35	25	25
Outcome C	0	5	5	5	10	5	45	35	10	5
Outcome D	0	0	0	0	0	0	15	0	0	0
Spring Chinook Salmon/Summer Steelhead Trout										
Outcome A	85	75	70	80	70	70	15	30	65	70
Outcome B	15	20	25	15	20	25	25	35	25	25
Outcome C	0	5	5	5	10	5	45	35	10	5
Outcome D	0	0	0	0	0	0	15	0	0	0
Winter Steelhead Trout										
Outcome A	80	70	65	80	65	65	10	25	65	65
Outcome B	15	20	25	15	25	25	20	30	25	25
Outcome C	5	10	10	5	10	10	50	35	10	10
Outcome D	0	0	0	0	0	0	20	10	0	0
Sea-run Cutthroat Trout										
Outcome A	80	70	65	80	65	65	10	25	65	65
Outcome B	15	20	25	15	25	25	15	25	25	25
Outcome C	5	10	15	5	15	15	45	45	15	15
Outcome D	0	0	0	0	0	0	30	10	0	0
Resident Rainbow/Cutthroat Trout										
Outcome A	80	70	60	80	60	60	10	20	60	60
Outcome B	15	20	25	15	25	25	15	25	25	25

Outcome B	15	20	25	15	25	25	15	25	25	25
Outcome C	5	10	15	5	15	15	45	45	15	15
Outcome D	0	0	0	0	0	0	30	10	0	0
Resident Rainbow/Cutthroat Trout	-									
Outcome A	80	70	60	80	60	60	10	20	60	60
Outcome B	15	20	25	15	25	25	15	25	25	25
Outcome C	0	10	15	5	15	15	45	45	15	15
Outcome D	0	0	0	0	0	0	30	10	0	0
Bull Trout										
Outcome A	90	85	85	85	85	85	35	45	85	85
Outcome B	10	15	15	15	15	15	35	25	15	15
Outcome C	0	0	0	0	0	0	20	25	0	0
Outcome D	0	0	0	0	0	0	10	5	0	0

A - Well Distributed B - Locally Restricted C - Restricted to Refugian D - Extirpation

Likelihoods of attaining outcome A were slightly higher for Option 8 than for Option 7 but were less than for the other options. Likelihoods of attaining outcome A ranged from 20-25 percent for all groups except bull trout, which was 45 percent, in Option 8. Option 8 has a lower likelihood of attaining outcome A than did options other than 7 because of the reduced size of Riparian Reserves (table V-4), particularly for intermittent streams.

This viability assessment of federal habitat does not directly correspond to population viability of the species considered. This is due, in part, to impacts or cumulative effects from nonfederal activities and to activities in other habitat sectors where the species might spend a portion of their life cycles. Furthermore, with. anadromous fish, there is very limited science available to establish direct relationships between land-management actions and population viability due, in part, to other impacts such as predation and artificial propagation and the difficulty of translating these impacts into population numbers.

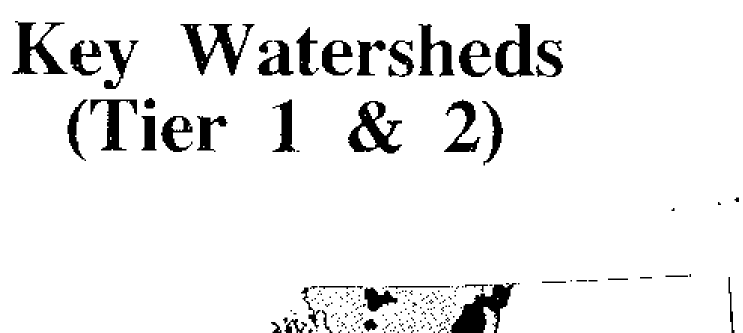
Mitigations

The higher likelihood of attaining outcome A for aquatic habitat on federal land under Options 1 and 4 stems from combining lower timber harvest levels with wider interim Riparian Reserve widths on non-Key Watershed intermittent streams than under any other options. For example, Option 9 received a 65 percent likelihood of attaining outcome A for fish habitat while Options 1 and 4 received greater than 80 percent likelihood of achieving outcome A. Option 9 designates 2.2 times more acres in the Matrix than Option 1 and 1.6 times more than Option 4. Under Option 9, 22 percent of the remaining late-succession forest is in the Matrix compared to zero percent in Option 1. In addition, Riparian Reserve 2 scenario is applied rather than the Riparian Reserve scenario 1 used in Options 1 and 4.

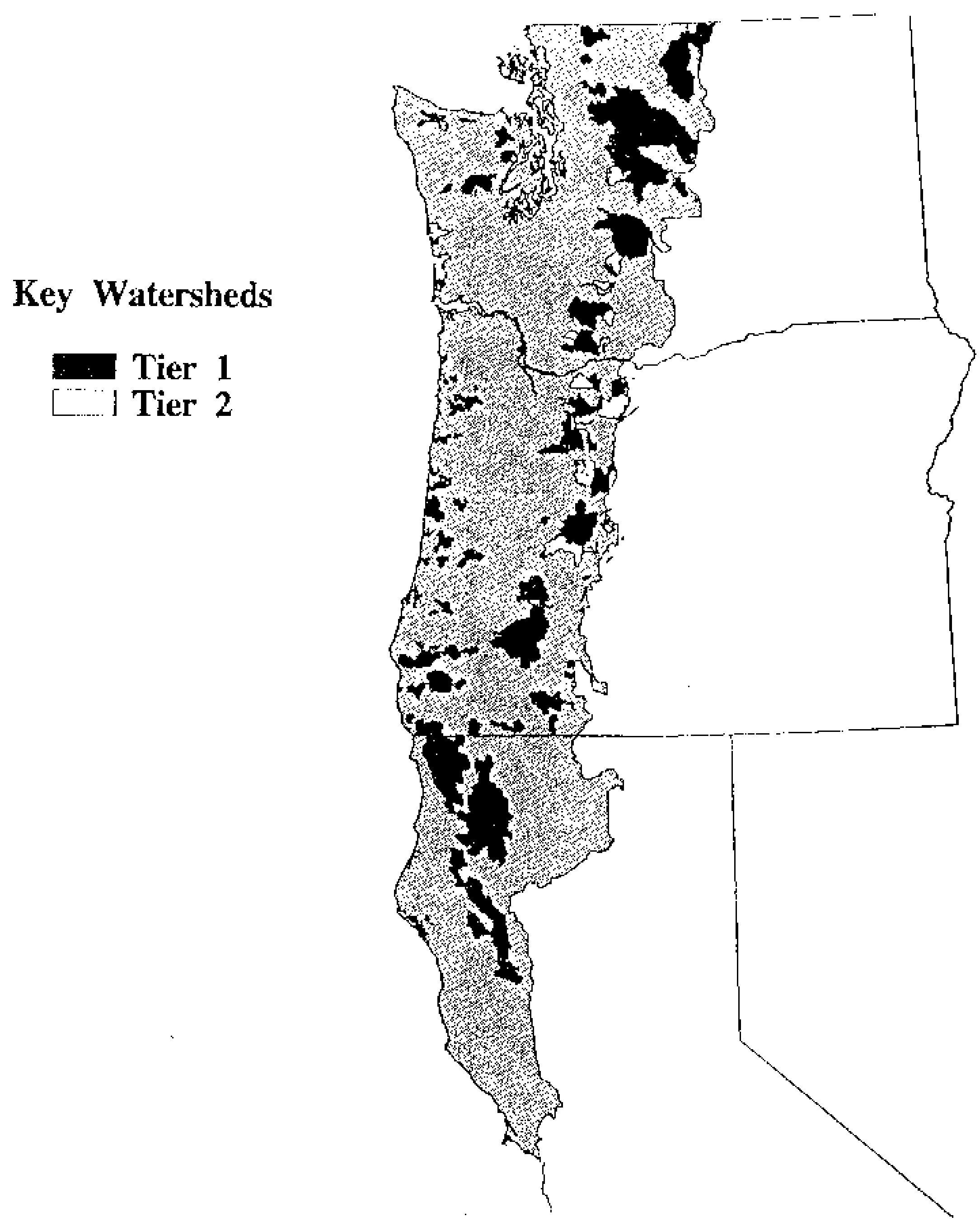
rhe primary difference between Riparian Reserve 1 and 2 scenarios is the interim width required for Riparian Reserves on intermittent streams in non-Key Watersheds. Interim Riparian Reserves for these streams in non-Key Watersheds are delineated using one site- potential tree height in Riparian Reserve 1 and one-half a site potential height in Riparian Reserve 2. In non-Key Watersheds, land-management activities can proceed outside Riparian Reserves before conducting a watershed analysis, thus the risk to aquatic and riparian habitat is, in part, determined by the interim width of these reserves.

To increase the likelihood of achieving outcome A for fish habitat of all races/species/groups to 80 percent or greater in Options 2, 3, 5, 6, 9, and 10, we recommend two possible strategies. One strategy is to replace the Riparian Reserve 2 scenario used in these options with the Riparian Reserve 1 scenario. Application of Riparian Reserve 1 scenario provides greater protection for fish habitat in non-Key Watersheds.

Major beneficiaries of such an action would be coastal area National Forests (Six Rivers, Siskiyou, Siuslaw, and Olympic National Forests) and Bureau of Land Management Districts (Salem, Eugene, and Coos Bay Districts). These coastal areas have a large number of at-risk anadromous salmonid stocks (appendix V-C), large areas of unstable land (figs V-1 - V-3), and a relatively small proportion of the total area in Key Watersheds compared to more inland areas (fig. V-25).



(Tier 1 & 2)



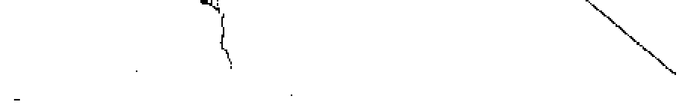


Figure V-25. Distribution of Key Watersheds within the range of the northern spotted owl.

A second mitigation strategy is to provide greater protection for Key Watersheds. This could be achieved by removing Key Watersheds from the timber-suitable base. Thus, land-management activities in these watersheds would be reduced, diminishing the potential for management generated disturbance. This additional protection is particularly important in the short-term since the relatively small amount of good habitat that remains is predominantly found in Key Watersheds.

Either of these mitigation strategies would probably be sufficient to increase the likelihood of achieving outcome A for fish habitat above 80% for all options except Option 7.

Summary and Conclusions

We have developed a conservation strategy for aquatic and riparian ecosystems based on scientific understanding of the functional links between stream and wetland ecosystems and adjacent terrestrial vegetation. Riparian forests may influence habitat structure and food resources of stream systems for lateral distances exceeding a tree height. Tree height distance away from the stream is a meaningful indicator of an area that is crucial for providing aquatic habitat components, including wood and shade. We defined a site- potential tree as the average maximum height of the tallest dominant trees (200 years or more) on a given site. In the owl forests, a site potential tree was modeled at 250 feet for the Oregon Coast and 170 feet for all other riparian forests west of the Cascades.

Another critical linkage within stream systems is the downstream movement of material and disturbances. Small, steep intermittently-flowing channels are often sources of large wood and boulders that enter larger, fish-bearing streams. Intermittent channels are also sites of land management-initiated debris flows originating from channel heads or road failures, which can severely degrade aquatic habitat. Intermittent streams have a defined channel that shows evidence of sediment deposition and scour. In this exercise, we estimated the number of these intermittent streams to be 90 percent greater than estimated in Forest Plans and Johnson et al. (1991).

The Aquatic Conservation Strategy has the following elements:

- Riparian Reserves to maintain ecological functions and protect stream and riparian habitat and water quality.
- A network of 162 Key Watersheds to protect at-risk fish stocks (139 Tier 1 Key Watersheds) or basins with outstanding water quality (23 Tier 2 Key Watersheds).
- No new roads will be constructed in all inventoried roadless areas in Key Watersheds to prevent further effects of roads as sources of sediment and flood flows.
- Watershed analysis, which is a procedure for planning further protection or management, including restoration practices within a basin.
- Restoration to speed ecosystem recovery in areas of degraded habitat and to prevent further degradation.

The Aquatic Conservation Strategy for Options 1 - 6 and 8 - 10 is summarized in table V-12.

Table V-12. Summary of Aquatic Conservation Strategy.

Component	Role in Conservation Strategy
Riparian Reserves	• Portions of the landscape where riparian dependent and stream resources receive primary emphasis • Designated for all permanently flowing streams, lakes, wetlands greater than one acre, and intermittent streams • Includes the body of water, inner gorge, all riparian vegetation, 100-year floodplain, landslides and landslide prone areas • Interim widths will be at least some fraction of a site potential tree or a prescribed slope distance (See Table V-5) • Standards and Guidelines prohibits programmed timber harvest, and manages roads, grazing, mining and recreation to achieve objectives of the Aquatic Conservation Strategy
Key Watersheds	• Tier 1 - Selected for directly contributing to anadromous salmonid and bull trout conservation • Tier 2 - May not contain at risks fish stocks but were selected as sources of high quality water • Inside roadless areas - no new roads will be built • Outside roadless areas - at a minimum, there will be no net increase in roads in Key Watersheds • Receives highest priority in restoration programs
Watershed Analysis	• A systematic procedure to characterize watersheds. The information guides management prescriptions, setting and refining Riparian Reserve boundaries, development of restoration strategies and monitoring programs. • Required in Key Watersheds prior to resource management • Required in all roadless areas prior to resource management • Recommended in all other watersheds • Required to change Riparian Reserve boundaries in all watersheds
Watershed Restoration	• Restore watershed processes to recover degraded habitat • Focus on road removal and upgrading • Silviculture treatments may be used to restore large conifers in Riparian Reserves • Restore channel complexity. In-stream structures should only be used in the short term and not as mitigation for poor land management practices

Riparian Reserves

Riparian Reserves are portion or watersheds where riparian-dependent resources receive primary emphasis and where special Standards and Guidelines apply. Riparian Reserves include those portions of a watershed that are directly coupled to streams and rivers that is, the portions of a watershed that directly affect streams, stream processes, and fish habitats. Every- watershed in National Forests and Bureau of Land Management Districts within the range of the northern spotted owl will have Riparian Reserves. Land allocated to Riparian Reserve status varies between options from 0.62 to 2.88 million acres depending on the forest management reserve alternative (table V-4).

Three scenarios were developed that define interim widths of Riparian Reserves (table V-5). One of these scenarios were used in each option. All options recognize at least three categories of w.ster: I) fish-bearing streams ~.nd lakes; 2) permanently flowing nonfish-bearing streams arid wetlands greater than one acre; and 3) intermittent streams and wetlands smaller than one acre.

The greatest difference among scenarios is in interim widths defined for intermittent streams. In both Riparian Reserve scenarios 1 and 3 the interim widths on intermittent streams do not vary between Key and non-Key Watersheds. However, the interim widths for these streams prescribed in scenario 1 are six times greater than in scenario 3 (table V-5). In Riparian Reserve scenario 2, interim widths within Tier 1 Key Watersheds are the same as in scenario 1. In all other watersheds, scenario 2 widths are one half those defined for scenario 1.

All options except Option 7 and 8 include either Riparian Reserve 1 or 2 scenarios. Both Riparian Reserve 1 and *2* institute an anti-degradation policy for aquatic systems on federal lands. Interim Riparian Reserves on all permanently flowing streams are wide enough to provide the full suite of ecological functions (figs V-12 - V-13) and include the floodplain, inner gorges, and unstable and potentially unstable lands. For non-Key Watersheds, interim reserve widths for Riparian Reserve 1 and 2 on intermittent streams are one or one-half site potential tree, respectively. Although these interim Riparian Reserve widths were estimated to be sufficient for providing full ecological effectiveness (fig. V-14), \VC assumed that there would be a greater risk to aquatic systems with the narrower reserves, in addition, the recovery rate may be slower in non-Key than in Key Watersheds due to less area in Late-Successional and other reserves and limited restoration funds.

Key Watersheds

A system of Key Watersheds that serve as refugia is critical for maintaining and recovering habitat for at-risk stocks of anadromous salmonids and resident fish species. These reftigia include areas of gooo habitat as well as areas of degraded habitat. Areas in good condition would serve as anchors for the potential recovery of depressed stocks. Those of lower quality habitat have a high potential for restoration and will become future sources of good habitat with the implementation of a comprehensive restoration program.

We identified a netwc,rk of 162 *KeN* Yatersheils (fig. V-25) located on federal lands including both Tier 1 Key Watersheds, selected specifically for directly contributing to the conservation of habitat for at-risk anadromous salmonids, bull trout, and resident fish species, and Tier 2 Key Watersheds, which are important sources of high quality water. These Key Watersheds vary in acreage in reserve status by option: The 139 Tier 1 Key Watersheds range between 70 - 86 percent in reserve status excluding Ripanian Reserves. The 23 Tier 2 Key Watersheds ranged between 62 - 82 percent in reserve status, excluding Riparian Reserves. The Key Watershed network occupies 36 percent of the federal land within the range of the northern spotted owl, or about 8.6 million acres.

We have indicated that all watersheds will recover watershed, nipanian, and aquatic processes, however, Key Watersheds should recover at a faster rate than others (fig. V-26). The large percent of Key Watersheds in Late-Successional and other reserved acres, interim Ripanian Reserves of one site-potential tree on intermittent streams in Tier 1 Key Watershed, and identification of Key Watersheds as priority sites for restoration increase the recovery rate in Key Watersheds.

It is important to consider the regional context of Key Watersheds. The Key Watershed network in northern California and the Cascades of Oregon and Washington is robust in terms of adjacency to wilderness watersheds, numbers and size of watersheds included and having a relatively even distribution of watersheds (fig. V-25). The Key Watershed network on the coasts of Oregon, Washington, and northern California is characterized by smaller and more isolated watersheds. Key Watersheds on the Olympic Peninsula and Siuslaw National Forest are well anchored by reserves. However, from the Humptulips River in Washington to the southern boundary the northern spotted owl range in California, major gaps in high quality habitat exist. The most productive forests in the region are contained in these coastal areas, which has resulted in intensive timber harvest on nonfederal lands. Therefore, Key Watersheds take on increased importance in these coastal areas given the likely continuation of intensive management on nonfederal forest lands, lack of state agricultural and forest practice regulations adequate to protect and restore aquatic ecosystems, and the large number of at-risk coastal salmonid species and stocks.

Management activities in roadless areas will increase the risk of aquatic and riparian habitat damage and potentially impair the capacity of Key Watersheds to function as intended and to contribute to achieving Aquatic Conservation Strategy Objectives. In order to protect the best habitat in Key Watersheds, all options except 7 and 8 stipulate no new roads will be constructed in roadless areas within Key Watersheds and watershed analysis must be completed for all watersheds within which a roadless area lies before management activities proceed in that roadless area.

Most timber-suitable roadless acreage can be harvested either directly from existing roads or using helicopters. Two miles is considered to be the economically operable distance for helicopter logging at today's lumber prices (Johnson et al. 1993, in prep.). Under Option 9, between 5000-10,000 acres of the timber-suitable Matrix of all inventoried roadless areas are beyond two miles from a road. We estimated that there were no stiitable acres for timber harvest in roadless areas within Key Watersheds that were further than this distance from existing roads. Thus, the requirement that no roads will be constructed in roadless areas within Key Watersheds should have no impact on total regional probable sale quantity. H all timber-suitable roadless remains unroaded in Option 9, then the estimated reduction for the total regional probable sale quantity is less than 0.2 percent.

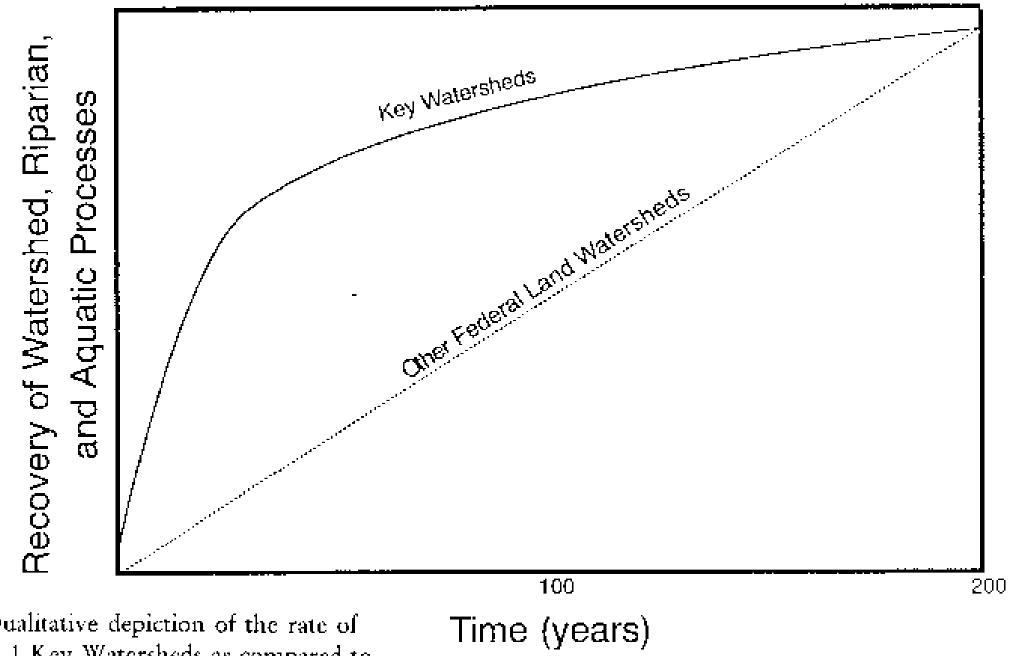


Figure V-26. Qualitative depiction of the rate of recovery for Tier 1 Key Watersheds as compared to other federal land watersheds. Faster recovery is due to the area of reserved lands, Riparian Reserves, and priority for restoration efforts.

Watershed Analysis

In planning for ecosystem management and establishing Riparian Reserves to protect and restore riparian and aquatic habitat, the overall watershed condition and the suite of processes operating there need to be considered. Watershed condition includes not only the state of the channel and riparian zone, but also the condition of the uplands, distribution and type of seral classes of vegetation, land use history, effects of previous natural and land-use related disturbances, and distribution and abundance of species and populations throughout the watershed. Watershed analysis is a systematic procedure for characterizing watershed and ecological processes to meet specific management and social objectives. This information then guides management prescriptions, including setting and refining boundaries of riparian and other reserves, sets restoration strategies and priorities, and reveals the most useful indicators for monitoring environmental changes. Watershed analysis is a stratum of ecosystem planning applied to watersheds of approximately 20-200 square miles. It provides a process for linking nonfederal and federal land coordination and planning.

Restoration

Watershed restoration must be an integral part of a program to aid recovery of fish habitat, riparian habitat, and water quality. The most important elements of a restoration program are: 1) control and prevent road-related runoff and sediment production; 2) improve the condition of riparian vegetation; and, 3) improve habitat structure in stream channels.

Of particular concern is that the federal lands within the northern spotted owl's range contain approximately 110,000 miles of roads. Much of this network adversely affects water quality and peak flow levels. The capacity of the U.S. Forest Service and Bureau of Land Management to maintain roads has declined dramatically as both appropriated and traffic-generated funds for maintenance and timber purchaser-conducted maintenance have been reduced. Without an active program of identifying and correcting problems, habitat damage will continue for decades.

Assessments of Future Habitat

In assessing the options, we considered five factors: (1) assessments of habitat conditions for the individual races/species/groups made by the Expert Panel; (2) amount of Riparian Reserves and type and level of land-management activity allowed within in them; and (3) extent of other reserves (e.g., Congressionally designated withdrawals, Late-successional Reserves, etc.); and type and level of land management activity allowed within them; (4) presence of a watershed restoration program; and (5) prescriptions for management of Matrix lands.

The analysis rated the sufficiency, quality, distribution and abundance of habitat to allow the species populations to stabilize across federal lands. In this assessment, Options 1 and *4* had the highest likelihood, 80 percent or greater, of attaining sufficient quality, distribution and abundance of habitat to allow the race/species/group to stabilize, well-distributed across federal lands (table V-12). The relatively high likelihood for these options was because of the large amount of area in reserves and the extent of Ripanian Reserves on all federal lands within the range of the northern spotted owl.

Options 2, 3, 5, 6, and 9 generally had a 60-70 percent likelihood of attaining outcome A. for all races/species/groups. These options had a smaller likelihood of attaining this outcome than Options 1 and *4* because of a combination of less area in reserves and smaller Rip anian Reserves. Options 7 and 8 had the lowest likelihoods of attaining outcome A for all races/species/groups. The likelihood for Option 7 ranged from 10-15 percent. Option 7 was ranked low primarily because of the low amount of nipanian reserves and the amount of activity that was allowed within them in Bureau of Land Management Land Management Plans and in many Forest Plans. Likelihoods for Option 8 obtaining outcome A ranged from 20-25 percent for all groups. Again, the reduced likelihood was due to reduced size of nipanian reserves, particularly in intermittent streams.

The likelihood of achieving outcome A for fish habitat is lower for Options 2,3,5,6,9, and 10 than for Options 1 and 4. However, we think all options except Option 7 an 8 will reverse the trend of degradation and begin recovery of aquatic ecosystems and habitat on federal lands within the range of the northern spotted owl. Even if changes in land management practices and comprehensive restoration are initiated, it is possible that no option will completely recover all degraded aquatic system within the next 100 years.

This assessment of Federal habitat does not directly correspond to population viability of the affected species. This is due, in part, to impacts or cumulative effects on species viability from nonfederal activities and to activities in other habitat sectors where the species might spend portions of their life cycle. Furthermore, with anadromous fish, there is very limited science available to establish direct relationships between land management actions and population viability due, in part, to other impacts such as predation and artificial propagation and the difficulty of translating these impacts into population numbers.

Finally, in considering the effects of any federal land management option on aquatic resources, two key points are important: 1) there are potentially other factors such as overutilization, disease, artificial propagation practices and other habitat impacts such as hydropower and irrigation developments that have degraded and continue to degrade aquatic habitat; and 2) a plan for managing federal lands will not solve problems caused on nonfederal land, and aquatic resources, for example, anadromous salmonids are adversely impacted by nonfederal actions. Ecosystem management cannot be successful without participation of all federal and nonfederal landowners and agencies that affect a watershed. The federal agencies must foster a partnership for ecosystem management with these entities in order to ensure conservation and prevent further degradation of the region's aquatic resources.

Probable Sale Quantity Implications of Mitigation

To increase the likelihood of achieving outcome A for fish habitat of all races/species/groups to 80 percent or greater in Options 2, 3, 5, 6, 9, and 10, we recommend two possible strategies. One strategy is to replace the Riparian Reserve 2 scenario used in these options with the Riparian Reserve 1 scenario. Application of Riparian Reserve 1 scenario provides greater protection for fish habitat in non-Key Watersheds. If Riparian Reserve 1 scenario were applied to Option 9, the probable sale quantity would be reduced approximately ten percent for federal lands within the range of the northern spotted owl (Johnson et al. 1993).

If the Riparian Reserve 2 scenario were replaced by Riparian Reserve 1 only in coastal areas, then the probable sale quantity for all federal lands within the range of the northern spotted owl would be reduced by 3-4 percent (30-40 million board feet) (Johnson et al. 1993). The Siuslaw National Forest would have the largest relative decrease in probable sale quantity.

A second mitigation strategy is to provide greater protection for Key Watersheds. This could be achieved by removing Key Watersheds from the timber-suitable base.
Removing Key Watersheds from the timber base would decrease the potential sale quantity for Options 2,3, 5, 6, 9, and 10 by approximately 15-20 percent (Johnson et al.
1993).

Proposed Screening Procedure for Short-term Sale Program and Volume Under Contract to Minimize Aquatic Ecosystem Impacts

A proposal is being developed to screen Sold and Awarded Sales' and "Prepared Sales to reduce effects on aquatic ecosystems. Our primary focus is directed toward the impact of sales in these two categories on moderate and high risk fish stocks in Key Watersheds and inventoried roadless areas. We believe the long-term risk to these fish stocks and water quality in other basins from sold sales is probably minimal. To reduce risks in non-Key Watersheds, prepared sales should be adjusted to interim widths of Riparian Reserves before proceeding. We recommend that a review team be assembled to screen these sales. The team should be interdisciplinary and include fish biologists, geomorphologists, or other physical scientists from various federal agencies and universities. The following approach addresses only aquatic concerns. Obviously, a complete analysis of these sales must take into account marbled murrelet, northern spotted owl and other considerations.

Summary of suggested approach:

For non-Key Watersheds, outside of roadless areas:

- Proceed with Sold and Awarded Sales.
- Adjust prepared sales, based on a site analysis, to interim widths of Riparian Reserves before proceeding.

For Key Watersheds and Inventoried Roadless Areas:

- Sold and Awarded Sales.
- If Moderate or High Risk fish stocks are not present, conduct a site analysis before proceeding.
- If Moderate or High Risk fish stocks are present, conduct an indepth review of sales and proceed unless an *unacceptably high physical risk* is present and sale cannot he adequately adjusted.
- Prepared sales
- If Moderate or High Risk fish stocks are not present and a low physical risk exists, adjust based on a site analysis to interim widths of Riparian Reserves before proceeding.
- If Moderate or Highgh Risk fish stocks are present, adjust based on a site analysis to interim widths of Riparian Reserves unless degree of physical risk warrants a watershed analysis before proceeding.

Much of the data required by this suggested approach is available. For example, stocks at risk (appendix V-C) and Key Watersheds (appendix V-H) have been identified. It is the duty of the interagency review team to determine how risk is defined; define thresholds such as Unacceptably High Physical Risk'; develop components of the site analysis; and ascertain when field review of sales is required. Undoubtedly, coordination with the technical team developing the Watershed Analysis Handbook will be necessary. All new sales must conform to the Aquatic Conservation Strategy.

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Appendix A

Physiographic Provinces and Subprovinces

The physiographic provinces (also referred to as provinces or "geoclimatic provinces) incorporate physical, biological and environmental factors that shape broad-scale - landscapes. Physiographic provinces reflect differences in geoloy (e.g., uplift rates, and recent volcanism, tectonic disruption) and climate (e.g., precipitation, temperature, and glaciation). These factors result in broad-scale differences in soil development and natural plant communities. Within each province, variable characteristics of rock stability affect steepness of local slopes, soil texture, soil thickness, drainage patterns, and erosional processes. Thus, physiographic provinces have utility in the description of both terrestrial and aquatic ecosystems.

Because terrestrial and aquatic ecosystems are dominated by different processes, the aquatic and terrestrial ecosystems working groups have used different physiographic province boundaries. In addition, state administrative boundaries have been incorporated into the provinces to reflect differences in land use and areas of analysis for past and current documents, including the Forest Ecosystems Management Assessment. Physiographic or geoclimatic provinces which integrate physical processes for both terrestrial and aquatic ecosystems are required. The hierarchy of provinces and subprovinces shown on figure V-A-i is based on the criteria discussed below.

Province boundaries (shown in bold lines) are based on long-term influences of geology and climate which are independent of the current climate. Past/current volcanism, glaciation, and tectonism/metamorphism have created physiographic effects on climate and dispersal patterns as well as physical (chemical and mechanical) processes.

Subprovince boundaries (shown in dashed lines) are based on the influence of the current climatic setting on soil development and biological processes.

Administrative (state) boundaries (shown in dotted lines) are retained to accommodate the description of land use patterns and analysis of data completed by the Forest Ecosystem Management Assessment Team.

Olympic Peninsula Province

The Olympic Peninsula in northwestern Washington is a mountainous region isolated on three sides by water and on the fourth side by an extensive region of cutover state and private lands (the Western Washington Lowlands). Streams flow outward from a central core of rugged mountains onto gently sloping lowlands. Landforms have been influenced by glaciation; main rivers flow in broad, U-shaped valleys, and peaks are surrounded by cirques. Steep slopes developed on resistant rocks are sublect to narrow, shallow rapid landslides (debris flows) originating from the heads of stream channels. Debris flows commonly scour steep tributary streams and deposit debris in fans on the valley floors. Unconsolidated glacial deposits are subject to accelerated stream bank erosion and landslides.

Vegetation and climate on the peninsula include a mixture of coniferous rain forests on the western slopes of the Olympic Mountains and relatively dry Douglas-fir forests in the rain shadow on the eastern slopes. This region is home to many species associated with late-successional/old-growth forests, including spotted owls, goshawks, marten and marbled murrelets. Although only a few nests have been found, large numbers of marbled murrelets are resident offshore and apparently nest on the peninsula. The dark, interior forest race of the northern goshawk occurs on the peninsula and mnay represent a unique subspecies.

The Olympic National Park occupies the interior of the Olympic Peninsula. It is surrounded by the Olympic National Forest, which is surrounded by extensive areas of private land, Indian reservations, and state owned lands. Much of the Olympic National Park consists of high-elevation forests and subalpine areas. However, lowland valleys within the park contain significant areas of late-successional/old-growth forest.

The Olympic National Forest is characterized by a fragmented mixture of clearcuts, young plantations, and natural forests ranging from young stands to stands more than 500 years old. The southern edge of the National Forest includes an extensive area referred to as the "Shelton Sustained Yield Unit, which was largely clearcut between 1960 and 1985. The National Forest includes several small wilderness areas on the east slope of the Olympic Range adjacent to the National Park. Most private lands, state lands, and Indian reservation lands on the peninsula have been clearcut within the last 80 years. Some of the latter areas are now being clearcut for the second time.

Puget/Willamette Trough Province

Western Washington Lowlands Subprovince (Puget Sound section)

Puget Sound is a depressed, glaciated area that is now partially submerged. Unconsolidated deposits of alluvial and glacial materials are subject to accelerated stream bank erosion and landslides. This area also includes extensive agricultural and metropolitan areas.

Willamette Valley Subprovince

The Willamette Valley includes the lowland valley area, which lies within a broad structural depression between the Coast Range and Cascade Range in western Oregon. The Willamette River meanders northward along a very gentle valley slope. Unconsolidated deposits of alluvia4 and glacial materials are subject to accelerated stream bank erosion and landslides. This area, which was originally covered by of a mosaic of lowland coniferous and deciduous forests and native prairie grasslands, was mostly cleared in the 1800's and early 1900's and converted to farmland, residential areas and metropolitan areas. Land ownership is largely private.

North Cascades Province

Western Washington Cascades Subprovince (North section) and Eastern Washington Cascades Subprovince (North section)

The North Cascades exhibit extremely high relief in comparison to other provinces (fig. V-1). Glaciers have carved deep and steep-sided valleys into both resistant and weak rocks. Tributaries flow at high angles into broad U-shaped valleys such as that occupied by Lake Chelan. Steep slopes are subject to debris flows from the heads of stream channels. Unconsolidated glacial and volcanic deposits are subject to accelerated stream bank erosion and landslides.

Lower and middle elevation forests of the Western Washington Cascades Subprovince (north section) consist primarily of Douglas-fir and western hemlock. The higher elevations support forests of silver fir and mountain hemlock. Although some National Parks and wilderness areas within this region include signific_nt a~eas of mid-elevation late-successional/old-growth forest, most are dominated -by high elevation areas of alpine or subalpine vegetation. The Eastern Washington Cascades Subprovince (north section) is dominated by mixed-conifer forests and ponderosa pine forests at mid- to lower elevations and by true fir forests at higher elevations.

High Cascades Province

The province consists of volcanic landforms with varying degrees of glaciation. Lava flows form relatively stable plateaus, capped by the recent Cascade volcanoes. Drainages are generally not yet well-developed or otherwise disperse into highly permeable volcanic deposits. Geologically recent volcanic deposits are subject to large debris flows when saturated by snowmelt.

Eastern Washington Cascades Subprovince (South section) and Eastern Oregon Cascades Subprovince

The higher elevations support forests of silver fir and mountain hemlock. Although some National Parks and wilderness areas within this region include significant areas of mid-elevation late-successional/old-growth forest, most are dominated by high elevation areas of alpine or subalpine vegetation. This area is dominated by mixed-conifer forests and ponderosa pine forests at mid- to lower elevations and by true fir forests at higher elevations.

Land ownership patterns include a mixture of Forest Service, private, state, Indian, National Park Service and Bureau of Land Management lands. Forests in this region are highly fragmented due to a variety of natural factors (e.g., poor soils, high fire frequencies, and~ high elevations) and human-induced factors (i.e., clearcutting and selective harvest).

Before the advent of fire suppression in the early 1900's, wildfires played a major role in shaping the forests of this region. Intensive fire suppression efforts in the last 60 years have resulted in significant fuel accumulations in some areas and shifts in tree species composition. These changes may have made forests more susceptible to large high severity fires and to epidemic attacks of insects and diseases. Any plan to protect late-successional/old-growth forests in this area must include considerable attention to fire management and to the stability of forest stands.

California (South) Cascades Subprovince

The California Cascades Subprovince includes the extreme southern end of the Cascades Range, which extends into California. Forests in this region are dominated by mixed conifer or ponderosa pine associations on relatively dry sites. Ownership is mixed with some areas of consolidated Forest Service lands and some areas of intermixed Forest Service and private lands. Forests are highly fragmented due to natural factors and harvest activities.

Fire plays an important role in the California Cascades in maintaining fire-adapted pine communities. Because of modern fire suppression, mixed conifer communities have increased, gradually replacing pine-dominated stands. If the objective is to manage a portion of the landscape in fire-dependent old-growth forests, then management must include understory thinning and understory burning.

Western Cascades Province

The Western Cascades are distinguished from the High Cascades by older volcanic activity and longer glacial history. Ridge crests at generally similar elevations are separated by steep, deeply dissected valleys. Complex eruption materials juxtapose relatively stable lava flows and volcanic deposits that weather to thick soils and are subject to earthflows. Unconsolidated alluvial and glacial deposits are subject to stream bank erosion and landslides. Tributary channels flow at large angles into wide, glaciated valleys. This region is dominated by humid forests of Douglas-fir and western hemlock.

Western Washington Cascades Subprovince (South section) and Western Oregon Cascades Subprovince

Forests of these subprovinces consist primarily of Douglas-fir and western hemlock at lower to middle elevations. Land ownerships include a mixture of private and state lands, National Forests. The Bureau of Land Management administers extensive areas in the Western Oregon Cascades Province. Private and state lands within this area are mostly cutover, whereas Federally administered lands still include significant areas (albeit highly fragmented) of late-successional/old-growth forest. Forests at the southern section of the subprovince are largely replaced by mixed conifer forests of Douglas-fir, grand fir and incense cedar.

A large proportion of the known spotted owl population in Washington and Oregon occurs in the Western Cascades. In Washington, old-growth forests on Federal lands in the Western Cascades are also important nesting habitat for marbled murrelets.

Washington/Oregon Coast Range Province

The southern part of the province generally consists of steep slopes with narrow ridges developed on resistant sedimentary rocks. Westward flowing streams erode headward to mountain passes on the east side of the Coast Range. Many of the higher peaks are composed of resistant igneous rocks. Steep, highly dissected slopes are subject to debris flows. Tributary channels joih at relatively low angles, which allow debris flows to travel for long distances. In the area drained by the Wilson and Trask Rivers in Oregon, weaker rocks form gentle slopes with thick soils that are subject to large, thick, slow-moving landslides (earthflows). Earthflows may constrict or deflect stream channels, creating local low-gradient stream reaches upstream.

Western Washington Lowlands Subprovince (Coast section)

The Western Washington Lowlands Subprovince includes western Washington south of the Olympic Peninsula. This area is largely in state and private ownership and has been almost entirely clearcut within the last 80 years. It is now dominated by a mixture of recent clearcuts and young stands on cutover areas. Forests on cutover areas are dominated by even-aged mixtures of Douglas-fir, western hemlock and red alder. The Western Washington Lowlands includes a major portion of the breeding range of the marbled murrelet in Washington.

Oregon Coast Range Subprovince

The subprovince includes the coastal mountains of western Oregon, from the Columbia River south to the Middle Fork of the Coquille River. This area is dominated by forests of Douglas-fir, western hemlock and western redcedar. The southern half of the subprovince includes a mixture of private lands, Forest Service lands and Bureau of Land Management lands. The northern half is largely in private and state ownership. Heavy cutting and several extensive wildfires during the last century have eliminated most old- growth forests in the northern end the province. Older forests in the southern half of the province are highly fragmented, especially on Bureau of Land Management lands, which are typically intermixed with cutover private lands in a checkerboard pattern of alternating square-mile sections.

Before the advent of fire suppression, the subprovince was subject to frequent fires. As a result, many of the remaining natural forests consist of a mosaic of mature stands and remnant patches of old-growth trees. Because it is isolated and heavily cutover, the area is of concern for spotted owls, marbled murrelets, and anadromous fish.

Klamath/Siskiyou Province

The Klamath/Siskiyou province is located in southwestern Oregon and northwestern California. The province is rugged and deeply dissected. Tributary streams generally follow the northeast-southwest orientation of rock structure created by accretion of rocks onto the continent. Variable materials juxtapose steep slopes subject to debris flows and gentle slopes sublect to earthflows. Scattered granitic rocks are subject to debris flows and severe surface erosion. High rates of uplift have created steep streamside hillslopes known as inner gorges, especially near the coast.

Oregon Klamath Subprovince and California Klamath Subprovince

This area is dominated by mixed conifer and mixed conifer/hardwood forests. Land ownerships include a mixture of Forest Service, Bureau of Land Management, private and state lands. Forests are highly fragmented by natural factors (e.g., poor soils, dry climate, and wildfires) and human-induced factors (e.g., harvest and roads). Much of the historical harvest in this area has been selective cutting rather than clearcutting. As a result, many stands that were logged in the early 1900's include a mixture of old trees left after harvest and younger trees that regenerated after harvest. Hillslope and channel disturbance due to mining activities began in the 1850's and still continues.

Much of the area within the Province is characterized by high fire frequencies. Any plan to protect late-successional/old-growth forests in these areas must include careful consideration of fire management.

East Klamath/Siskiyou Subprovince

Climatic and vegetation gradients indicate that this additional subprovince be added to the classification, but it has not been incorporated into the present analysis.

Franciscan Province

California Coast Range Subprovince and Oregon Franciscan Subprovince

The Oregon Franciscan Subprovince includes a coastal strip that extends from south of Coos Bay to the Oregon/California border. Geologic and climatic factors indicate that this additional subprovince be added to the classification, but it has not been incorporated into the present analysis. The California Coast Range Subprovince includes the coastal strip that extends from the Oregon border south to Mann County, California.

The Franciscan Province consists of accreted rocks, with structural discontinuities reflected in general stream orientations of northwest-southeast. Relatively rapid tectonic uplift has caused the dissected stream channels to become incised, creating inner gorges. Weak rocks are highly fractured along numerous faults and contacts and are weathered to deep soils that are subject to extensive earthflows. Sediment transport rates are among the highest in the world.

This area is dominated by redwood forests and mixed forests of Douglas-fir and hardwoods. Most of the area is privately owned, but Forest Service lands, Bureau of Land

Management lands and state and Federal parks are also present. This area includes the coastal fog belt in which grow the last remaining stands of old-growth redwoods. Considerable numbers of spotted owls occur on private lands in the area. In addition, this is an important nesting area for murrelets.

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Appendix B

Appendix V-B
Common and Scientific Names of Fish Discussed in the Chapter

Chinook salmon	*Oncorhynchus tshawytscha*
Coho salmon	*O. kisutch*
Sockeye salmon	*O. nerka*
Chum salmon	*O. keta*
Pink salmon	*O. gorbuscha*
Steelhead trout	*O. mykiss gairdneri*
Sea-run Cutthroat trout	*O. clarki clarki*
Rainbow trout	*O. mykiss*
Redband trout	*O. mykiss spp.*
Cutthroat trout	*O. clarki*
Pacific lamprey	*Lampetra tridentata*
Bull trout	*Salvelinus confluentus*
Dolly varden	*S. malma*
Mountain whitefish	*Prosopium williamsoni*
Umpqua chub	*Oregonichthys kalawatseti*
Oregon chub	*Oregonichthys crameri*
Umpqua squawfish	*Ptychocheilus umpquae*

Bull trout	*Salvelinus confluentus*
Dolly varden	*S. malma*
Mountain whitefish	*Prosopium williamsoni*
Umpqua chub	*Oregonichthys kalawatseti*
Oregon chub	*Oregonichthys crameri*
Umpqua squawfish	*Ptychocheilus umpquae*
Olympic mudminnow	*Novumbra hubbsi*
Longnose dace	*Rhinichthys cataractae*
Millicoma dace	*R. cataractae spp.*
Reticulate sculpin	*Cottus perplexus*
Paiute sculpin	*C. beldingi*
Riffle scuplin	*C. gulosus*
Shorthead sculpin	*C. confusus*
Torrent sculpin	*C. rhotheus*
Mottled sculpin	*C. bairdi*
Coastrange sculpin	*C. aleuticus*
Jenny Creek sucker	*Catostomus rimiculus spp.*
Salish sucker	*Catostomus sp.*
Klamath short-nose sucker	*Chasmistes brevirostris*
Lost River sucker	*Deltistes luxatus*
Redside shiner	*Richardsonius balteatus*

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Appendix C

Appendix V-C
At-Risk Anadromous Fish Stocks

This appendix: 1) Identifies the risk rating criteria for the individual stocks listed in different reports (table V-C-1); 2) gives the total numbers of individual at-risk stocks of anadromous salmonid found on federal and nonfederal lands within the range of the northern spotted owl (table V-C-3). The list was compiled from: Nehlsen et al. (1991), Higgins et al. (1992), Nickelson et al. (1992), and Washington Department of Fisheries et al. (1992).

Although the risk ratings are not exactly comparable between reports, we compiled them in the following way:

Table V-C-1. Risk rating criteria.

Risk Rating	Nehlsen et al.	Higgins et al.	Nickelson et al.	Washington Dept. of Fisheries et al.
0	--	--	--	Extinct
1	High Risk of Extinction (A)	High Risk of Extinction (A)	Special Concern	Critical
2	Moderate Risk of Extinction (B)	Moderate Risk of Extinction (B)	Depressed	Depressed
3	Special Concern (C)	Special Concern (C)	--	--
4	--	--	Unknown	Unknown
5	--	--	Healthy	Healthy

Table V-C-2. Number of stocks at risk (a) on federal and nonfederal lands within the range of the northern spotted owl

4	--	--	Unknown	Unknown
5	--	--	Healthy	Healthy

Table V-C-2. Number of stocks at risk (a) on federal and nonfederal lands within the range of the northern spotted owl.

Race	Forest Service (b)	Bureau of Land Management (b) (c)	National Park Service (c)	Total on federal lands	Total on Nonfederal lands
Spring/Summer Chinook salmon	39	3	0	42	1
Fall Chinook salmon	32	2	1	35	3
Coho salmon	59	11	1	71	27
Sockeye salmon	1	0	2	3	3
Chum salmon	21	2	1	24	4
Pink salmon	5	0	0	6	1
Winter Steelhead	34	4	0	38	16
Summer Steelhead	35	0	0	35	0
Sea-run Cutthroat trout	4	1	0	5	0
Total	231	23	5	259	55

[a] At risk is defined here as stocks rated as either 1 or a 2 by one or more of the reports used in constructing this chart.
[b] Includes basins in which the Forest Service and/or BLM land is not accessed by anadromous fish due to natural barriers, dams, or placement of federal land within basin. Many of these are important in maintaining water quality for anadromous fish runs.
[c] Counts basins in which the BLM or National Park Service manages land only if the Forest Service does not.

APPENDIX C: At-Risk Anadromous Fish Stocks

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Although the risk ratings are not exactly comparable between reports, we compiled them in the following way

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0	–	–	–	Extinct
1	High Risk of Extinction (A)	High Risk of Extinction (A)	Special Concern	Critical
2	Moderate Risk of Extinction (B)	Moderate Risk of Extinction (B)	Depressed	Depressed
3	Special Concern (C)	Special Concern (C)	–	–
4	--	–	Unknown	Unknown
5	--	–	Healthy	Healthy

Table V-C-2. Number of stocks at risk (a) on federal and nonfederal lands within the range of the northern spotted owl.

Race	Forest Service (b)	Bureau of Land Management (b) (c)	National Park Service (c)	Total on federal lands	Total on Nonfederal lands
Spring/Summer Chinook	39	3	0	42	1

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Spring/Summer Chinook salmon	39	3	0	42	1
Fall Chinook salmon	32	2	1	35	3
Coho salmon	59	11	1	71	27
Sockeye salmon	1	0	2	3	3
Chum salmon	21	2	1	24	4
Pink salmon	5	0	0	6	1
Winter Steelhead	34	4	0	38	16
Summer Steelhead	35	0	0	35	0
Sea-run Cutthroat trout	4	1	0	5	0
Total	231	23	5	259	55

a At risk is defined here as stocks rated as either 1 or a 2 by one or more of the reports used in constructing this chart.

b Includes basins in which the Forest Service and/or BLM land is not accessed by anadromous fish due to natural barriers, dams, or placement of federal land within basin. Many of these are important in maintaining water quality for anadromous fish runs.

c Counts basins in which the BLM or National Park Service manages land only if the Forest Service does not.

Table V-C-3. Anadromous salmonid stocks at risk within the range of the northern spotted owl.

Race	Stock	Nehlsen et al.	Higgins et al.	Nickelson et al.	WA Dept. of Fisheries et al.	BLM Districts	National Forests	Key Watersheds
Winter Chinook								
California								
	Sacramento (E)	see footnote				Ukiah	Shasta-Trinity(A), Mendocino(A and/or B)	
Spring/Summer Chinook								
California								
	Klamath/Salmon (spr)	1	1			Ukiah	Six Rivers, Klamath, Shasta-Trinity, (Hoopa Indian Res.)	CF-143-146,149-154 CF-156-161

California							
Sacramento (E)	see footnote				Ukiah	Shasta-Trinity(A), Mendocino(A and/or B)	
Spring/Summer Chinook							
California							
Klamath/Salmon (spr)	1	1			Ukiah	Six Rivers, Klamath, Shasta-Trinity, (Hoopa Indian Res.)	CF-143-146,149-154 CF-156-161
Trinity (spr)		3			Ukiah	Six Rivers, Shasta-Trinity	CF-143-146,153,154
S. Fk. Trinity (spr)		1				Six Rivers, Shasta-Trinity	CF-145,153
Smith (spr)	1	1				Six Rivers	CF-155,OF-44
Oregon							
Coquille (spr)	1		2		Coos Bay, Roseburg	Siskiyou	OU-59;OB-60,61
S. Umpqua (spr)	1		2		Roseburg, Medford	Umpqua	OU-86
Siuslaw (spr)			4		Eugene	Siuslaw	OF-68-70
Alsea (spr)	3		5		Salem, Eugene	Siuslaw	OU-73;OB-74,75
Siletz (spr/su)	3		5		Salem	Siuslaw	OU-77;OB-78
Nestucca (spr)			1		Salem	Siuslaw	OB-79;OF-80-82
Tillamook Bay							
Trask (spr)			1		Salem, (Tillamook SF)		OB-85
Wilson (spr)			1		Salem, (Tillamook SF)		OB-84
Kilchis (spr)			1		Salem, (Tillamook SF)		OB-83
Nehalem (su)	3		5		Salem, (Tillamook SF) (Clatsop SF)		
Columbia							
Willamette (spr)	3				Salem, Eugene	Willamette, Mt. Hood	OF-110,112-116; OB-117;OU-110
Sandy (spr)	1				Salem	Mt. Hood	OU-127;OF-128
Hood (spr)	1				Prineville	Mt. Hood	OF-119
Washington							
Yakima							
Upper Yakima (spr)				2		Wenatchee	WF-11
Naches (spr)				2		Wenatchee	WF-11-13
American (spr)				2		Wenatchee	WF-13
Wenatchee (su)				5	Spokane	Wenatchee	WF-15-18
Chiwawa (spr)				2		Wenatchee	WF-18
Lt. Wenatchee (spr)				2		Wenatchee	WF-18
Nason Cr. (spr)				2		Wenatchee	
White (spr)				2		Wenatchee	WF-18
Entiat (spr)				2	Spokane	Wenatchee	WF-19
Methow (su)	2			2	Spokane	Okanogan	WF-20-22
Methow (spr)				2	Spokane	Okanogan	WF-20-22
Twisp (spr)				2	Spokane	Okanogan	WF-20
Lost (spr)				2		Okanogan	WF-21
Chewack (spr)				2		Okanogan	WF-22
Okanogan (su)	3			2	Spokane	Okanogan	
WA Coast							
Grays Harbor/Chehalis							
Satsop (su)				2		Olympic, (Olympic NP)	WF-34
Wynoochee (spr)	1			5		Olympic, (Olympic NP)	WF-33
Quinault (spr)				2		Olympic, (Olympic NP), (Quinault Indian Res.)	WF-41
Queets (spr)				2		Olympic, (Olympic NP),	

	Chewack (spr)				2			
	Okanogan (su)	3			2	Spokane	Okanogan	
	WA Coast							
	Grays Harbor/Chehalis							
	Satsop (su)				2		Olympic, (Olympic NP)	WF-34
	Wynoochee (spr)	1			5		Olympic, (Olympic NP)	WF-33
	Quinault (spr)				2		Olympic, (Olympic NP), (Quinault Indian Res.)	WF-41
	Queets (spr)				2		Olympic, (Olympic NP), (Quinault Indian Res.)	
	Clearwater (spr)				2		(Quinault Indian Res.)	
	Quillayute (su)				4		Olympic, (Olympic NP)	WF-40
	Quill./Bogachiel (su)				4		Olympic, (Olympic NP)	
	Calawah (su)				4		Olympic, (Olympic NP)	
	Strait of Juan de Fuca							
	Elwha (spr)	1					Olympic(A), (Olympic NP)	WF-39
	Dungeness (spr) (SASSI is for spr/su)	1			1		Olympic, (Olympic NP)	WF-38
	Hood Canal							
	Dosewallips (spr)	1					Olympic, (Olympic NP)	WF-37
	Skokomish	1					Olympic, (Olympic NP), (Skokomish Indian Res.)	WF-35,42

Table V-C-3. (Continued).

Race	Stock	Nehlsen et al.	Higgins et al.	Nickelson et al.	WA Dept. of Fisheries et al.	BLM Districts	National Forests	Key Watersheds
Spring/Summer Chinook (continued)								
	Puget Sound							
	Puyallup							
	White (spr)	2			1		Mt. Baker-Snoqualmie, (Mt. Rainier NP)	WF-23
	White (su/fall)				4		Mt. Baker-Snoqualmie, (Mt. Rainier NP)	WF-23
	Lake Washington							
	N.Lk.Wa. tribs. (su/fall)				4			
	Cedar (su/fall)				4		(City of Seattle)	
	Snohomish (su)				2		Mt. Baker-Snoqualmie	WF-24,25
	Stillaguamish (su)				2	Spokane	Mt. Baker-Snoqualmie	WF-26-28
	Stillaguamish (spr)	1				Spokane	Mt. Baker-Snoqualmie	WF-26-28
	Skagit							
	Lower Sauk (su)				2		Mt. Baker-Snoqualmie	WF-29
	Suiattle (spr)				2		Mt. Baker-Snoqualmie	WF-30
	Upper Cascade (spr)				4		Mt. Baker-Snoqualmie, (N. Cascades NP)	
	Nooksack							
	N. Fk. Nooksack	1			1		Mt. Baker-Snoqualmie, (N. Cascades NP), (Lummi Indian Res.)	WF-32
	S. Fk. Nooksack	1			1		Mt. Baker-Snoqualmie, (Lummi Indian Res.)	WF-31
Fall Chinook								
	California							

Nooksack							
N. Fk. Nooksack	1			1		Mt. Baker-Snoqualmie, (N. Cascades NP), (Lummi Indian Res.)	WF-32
S. Fk. Nooksack	1			1		Mt. Baker-Snoqualmie, (Lummi Indian Res.)	WF-31
Fall Chinook							
California							
Mattole	1	1			Ukiah, Arcata, (King Range NCA)		CB-162
Russian	1						
Bear		3					
Eel		3			Ukiah, (Humboldt Redwoods SP)	Mendocino, Six Rivers, (Round Valley Indian Res.)	CF-140-142,147
Lower Eel (H)	2				Ukiah, (Humboldt Redwoods SP)	Six Rivers(B)	CF-147
Humboldt Bay tribs.	1	1			Ukiah		
Mad	2	3			Ukiah	Six Rivers	CF-148
Little R.		3					
Redwood Cr.	2	3			Ukiah	Six Rivers(B), (Redwood NP)	
Klamath							
Lower Klamath tribs. (G)	2	2			Ukiah	Six Rivers, (Hoopa Indian Res.)	CF-151
Trinity	3				Ukiah	Six Rivers, Shasta-Trinity	CF-143-146 153,154
S. Fk. Trinity		3				Six Rivers, Shasta-Trinity	CF-145,153
Scott	3	3			Ukiah	Klamath	
Shasta	1	1			Ukiah	Shasta-Trinity(A), Klamath(A)	
Smith	2					Six Rivers, Siskiyou	
Oregon							
Winchuck	2		2			Siskiyou	OF-45
Chetco			1		Coos Bay	Siskiyou	OF-46;OB-47
Pistol	2		2		Coos Bay	Siskiyou	
Hunter Cr.	1		2		Coos Bay	Siskiyou	
Rogue							
Lower Rogue tribs. (I)	1		2		Coos Bay	Siskiyou	OF-51-54,56;OU-55
Illinois			2		Medford	Siskiyou	OF-51-54,56;OU-55
Euchre Cr.	1		2		Coos Bay	Siskiyou	
Elk			1		Coos Bay	Siskiyou	OF-57
Sixes			1		Coos Bay	Siskiyou	OF-58
New R.							
Floras Cr.			4		Coos Bay		
Coos	3		5		Coos Bay, (Elliot SF)		OB-62
Big Cr.			4			Siuslaw	OF-71
Yachats	2		4		Salem	Siuslaw	OF-72
Beaver Cr.			4		Salem	Siuslaw	
Yaquina	3		5		Salem	Siuslaw	OF-76
Drift Cr. (Siletz Bay)			4		Salem	Siuslaw	OU-77
Schooner Cr.			4		Salem	Siuslaw	
Salmon			1		Salem	Siuslaw	
Neskowin Cr.			4			Siuslaw	
Nehalem			5		Salem, (Tillamook SF),		

Race	Stock	Nehlsen et al.	Higgins et al.	Nickelson et al.	WA Dept. of Fisheries et al.	BLM Districts	National Forests	Key Watersheds
	Yachats	2		4		Salem	Siuslaw	OF-72
	Beaver Cr.			4		Salem	Siuslaw	
	Yaquina	3		5		Salem	Siuslaw	OF-76
	Drift Cr. (Siletz Bay)			4		Salem	Siuslaw	OU-77
	Schooner Cr.			4		Salem	Siuslaw	
	Salmon			1		Salem	Siuslaw	
	Neskowin Cr.			4			Siuslaw	
	Nehalem			5		Salem, (Tillamook SF),		

Table V-C-3. (Continued).

Race	Stock	Nehlsen et al.	Higgins et al.	Nickelson et al.	WA Dept. of Fisheries et al.	BLM Districts	National Forests	Key Watersheds
						(Clatsop SF)		
Fall Chinook (continued)								
	Salmonberry			4		(Tillamook SF), (Clatsop SF)		
	Columbia							
	Sandy	1					Mt. Hood(B)	OU-127;OF-128
	Hood	1				Prineville	Mt. Hood	OF-119
	L.Columbia (small tribs.)	1				Salem, Prineville, Spokane	Mt. Hood, Gifford Pinchot(B)	OF-118,120;WF-3
	Washington							
	Cowlitz	1					Gifford Pinchot(A)(C)	WF-7-10
	Toutle						Gifford Pinchot	
	Green				2		Gifford Pinchot, (Mt. St. Helens NVM)	
	S. Fk. Toutle				2		Gifford Pinchot, (Mt. St. Helens NVM)	
	Washougal	1					Gifford Pinchot(B)	
	Wind (tule)				2		Gifford Pinchot	WF-1
	White Salmon (SASSI rating for tule)	1			2		Gifford Pinchot(B)	WF-5
	WA Coast							
	Willapa Bay							
	North R.							
	Fall R. (early)				2			
	Grays Harbor							
	Johns/Elk/S. Bay tribs.				4			
	Copalis				4			
	Moclips				4		(Quinault Indian Res.)	
	Raft				4		(Quinault Indian Res.)	
	Ozette R.	1					(Olympic NP)	
	Strait of Juan de Fuca							
	Dungeness	1					Olympic, (Olympic NP)	WF-38
	Hoko				2			
	Hood Canal							
	Dosewallips	1					Olympic, (Olympic NP)	WF-37
	Duckabush	1					Olympic, (Olympic NP)	WF-36
	Puget Sound							
	Puyallup	3			4		Mt. Baker-Snoqualmie, (Puyallup Indian Res.), (Muckleshoot Indian Res.)	WF-23

	Dungeness	1					Olympic, (Olympic NP)	[illegible]
	Hoko				2			
	Hood Canal							
	Dosewallips	1					Olympic, (Olympic NP)	WF-37
	Duckabush	1					Olympic, (Olympic NP)	WF-36
	Puget Sound							
	Puyallup	3			4		Mt. Baker-Snoqualmie, (Puyallup Indian Res.), (Muckleshoot Indian Res.)	WF-23
	Snohomish				2		Mt. Baker-Snoqualmie	WF-24,25
	Bridal Veil Cr.				4			
	Stillaguamish				2	Spokane	Mt. Baker-Snoqualmie	WF-26-28
	Skagit							
	Lower Skagit mainstem and tribs.				2	Spokane	Mt. Baker-Snoqualmie, (N. Cascades NP)	
Coho								
	California							
	Russian		1					
	CA small coastal N. of S.F.	2						
	Pudding Cr.		1					
	Gualala		1					
	Garcia		1					
	Navarro		3					
	Albion		3					
	Big		3			(Jackson SF)		
	Noyo		3					
	Ten Mile		3					
	Bear		3					
	Little		3					
	Wilson Cr.		3				(Redwood NP)	
	Mattole		1			Ukiah, Arcata, (King Range NCA)		CB-162
	Eel		3			Ukiah	Mendocino, Six Rivers (Round Valley Indian Res.)	CF-140-142,147
	Humboldt Bay tribs.		3					
	Mad		1			Ukiah	Six Rivers	CF-148
	Redwood Cr.		3			Ukiah	Six Rivers(B), (Redwood NP)	
	Klamath	3				Ukiah	Six Rivers, Klamath, Shasta-Trinity,	CF-143-146,149-154, 156-161

Table V-C-3. (Continued).

Race	Stock	Nehlsen et al.	Higgins et al.	Nickelson et al.	WA Dept. of Fisheries et al.	BLM Districts	National Forests	Key Watersheds
Coho (continued)								
	Lower Klamath tribs. (G)		3				(Hoopa Indian Res.) Six Rivers, (Hoopa Indian Res.)	CF-151
	Trinity		[illegible]					

Table V-C-3. (Continued).

Race	Stock	Nehlsen et al.	Higgins et al.	Nickelson et al.	WA Dept. of Fisheries et al.	BLM Districts	National Forests	Key Watersheds
Coho (continued)							(Hoopa Indian Res.)	
	Lower Klamath tribs. (G)		3				Six Rivers, (Hoopa Indian Res.)	CF-151
	Trinity		3			Ukiah	Six Rivers, Shasta-Trinity	CF-143-146,153,154
	Scott		1			Ukiah	Klamath	
	Oregon							
	Small OR coastal tribs.			2		Coos Bay, Eugene, Salem	Siskiyou, Siuslaw	OF-71
	Winchuck	1		2			Siskiyou	OF-45
	Chetco	1		2		Coos Bay	Siskiyou	OF-46;OB-47
	Pistol	1		2		Coos Bay	Siskiyou	
	Hunter			2		Coos Bay	Siskiyou	
	Rogue	1				Coos Bay, Medford	Siskiyou, Rogue River	OF-48-54,56,98-101; OU-55,96,97
	Lower Rogue (I)			2		Coos Bay	Siskiyou	OF-49
	Middle Rogue (J)			2		Medford, Coos Bay	Siskiyou, Rogue River	OF-48,50,98-101;
	Upper Rogue (K)			2		Medford	Rogue River	OU-96,97
	Illinois			2		Medford	Siskiyou	OF-51-54,56;OU-55
	Applegate			2		Medford	Rogue River	OF-98-101
	Euchre Cr.			2		Coos Bay	Siskiyou	
	Elk	1		2		Coos Bay	Siskiyou	OF-57
	Sixes	1		2		Coos Bay	Siskiyou	OF-58
	New R.							
	New R. tribs.			2		Coos Bay		
	Floras Cr.	1				Coos Bay		
	Coquille	2		5		Coos Bay	Siskiyou	OU-59;OB-60,61
	S. Fk. Coquille			2		Coos Bay	Siskiyou	OU-59
	Coos	2		5		Coos Bay		OB-62
	Millicoma			2				
	Tenmile Cr.			2			Siuslaw	
	Umpqua	2				Coos Bay, Roseburg, Medford	Siuslaw, Umpqua	OF-63,65,66,87-89, 91,92;OB-64,67,93, 94;OU-86,90
	Lower Umpqua			2		Coos Bay	Siuslaw	OF-63,65,66; OB-64,67
	Smith			2		Coos Bay, Roseburg, Eugene	Siuslaw	OF-65,66;OB-67
	N. Umpqua			1		Roseburg	Umpqua	OF-87-89,91,92; OU-90
	S. Umpqua			2		Roseburg	Umpqua	OU-86
	Siuslaw	2		2		Eugene	Siuslaw	OF-68-70
	N. Fk. Siuslaw			2		Eugene	Siuslaw	OF-68
	Yachats	2		2		Salem	Siuslaw	OF-72
	tribs. S. of Alsea			2		Coos Bay, Eugene, Salem	Siskiyou, Siuslaw	OF-71
	Alsea	2		5		Salem	Siuslaw	OU-73;OB-74,75
	Drift Cr. (Alsea)			5		Salem	Siuslaw	OU-73
	tribs. N. of Alsea			2		Salem	Siuslaw	

	S. Umpqua			2		Roseburg	Umpqua	OU-86
	Siuslaw	2		2		Eugene	Siuslaw	OF-68-70
	N. Fk. Siuslaw			2		Eugene	Siuslaw	OF-68
	Yachats	2		2		Salem	Siuslaw	OF-72
	tribs. S. of Alsea			2		Coos Bay, Eugene, Salem	Siskiyou, Siuslaw	OF-71
	Alsea	2		5		Salem	Siuslaw	OU-73;OB-74,75
	Drift Cr. (Alsea)			5		Salem	Siuslaw	OU-73
	tribs. N. of Alsea			2		Salem	Siuslaw	
	Beaver Cr.	2		2		Salem	Siuslaw	
	Yaquina			2		Salem	Siuslaw	OF-76
	Schooner Cr.			4		Salem	Siuslaw	
	Siletz	2		2		Salem	Siuslaw	OB-78
	Drift Cr. (Siletz Bay)			4		Salem	Siuslaw	OU-77
	Salmon	2		2		Salem	Siuslaw	
	Nestucca	2		2		Salem	Siuslaw	OB-79;OF-80-82
	Little Nestucca			2		Salem	Siuslaw	
	tribs. S. of Tillamook Bay (and N. of Alsea)			2		Salem	Siuslaw	
	Tillamook Bay	2				Salem, (Tillamook SF)		
	small Tillamook Bay tribs.			4		Salem		
	Trask			2		Salem, (Tillamook SF)		OB-85
	Wilson			2		Salem, (Tillamook SF)		OB-84
	Kilchis			2		Salem, (Tillamook SF)		OB-83
	Miami			2		(Tillamook SF)		
	Tillamook			2		Salem		
	tribs. N. of Tillamook Bay			4		Salem		

Table V-C-3. (Continued).

Race	Stock	Nehlsen et al.	Higgins et al.	Nickelson et al.	WA Dept. of Fisheries et al.	BLM Districts	National Forests	Key Watersheds
Coho (continued)								
	Nehalem	2				Salem, (Tillamook SF), (Clatsop SF)		
	Lower Nehalem			2		(Tillamook SF)		
	N. Fk. Nehalem			1		(Tillamook SF), (Clatsop SF)		
	Salmonberry			4		(Tillamook SF), (Clatsop SF)		
	Upper Nehalem			2		Salem, (Tillamook SF), (Clatsop SF)		
	Elk Cr.	2		2				
	Necanicum	2		2				
	Columbia							
	Willamette							
	Clackamas	2				Salem	Mt. Hood	OF-121-125; OU-126
	Sandy	1				Salem	Mt. Hood	OU-127;OF-128
	Hood	1				Prineville	Mt. Hood	OF-119
	L. Columbia tribs	1				Salem, Prineville,	Mt. Hood, Gifford Pinchot	OF-118,120;WF-3

Elk Cr.						
Necanicum	2	2				
Columbia						
Willamette						
Clackamas	2			Salem	Mt. Hood	OF-121-125; OU-126
Sandy	1			Salem	Mt. Hood	OU-127;OF-128
Hood	1			Prineville	Mt. Hood	OF-119
L. Columbia tribs.	1			Salem, Prineville, Spokane	Mt. Hood, Gifford Pinchot	OF-118,120;WF-3
L. Columbia small tribs. above Bonneville Dam			2	Prineville, Spokane	Mt. Hood, Gifford Pinchot	OF-118,120;WF-3
Washington						
Grays R.			2			
Skamokawa Cr.			2			
Elochoman			2			
Mill Cr.			2			
Abernathy Cr.			2			
Germany Cr.			2			
Cowlitz			2		Gifford Pinchot(A)(C)	WF-7-10
Toutle			2		Gifford Pinchot	
S. Fk. Toutle			2		Gifford Pinchot	
Green			2		Gifford Pinchot	
Coweeman			2			
Kalama			2		Gifford Pinchot (B), (Mt. St. Helens NVM)	
Lewis			2	Spokane	Gifford Pinchot (A)	WF-2,6
E. Fk. Lewis			2	Spokane	Gifford Pinchot	WF-2
Salmon Cr.			2			
Washougal	1		2	Spokane	Gifford Pinchot (B)	
WA Coast						
Willapa Bay	1		4			
Copalis			4			
Moclips			4		(Quinault Indian Res.)	
Quinault			4		Olympic, (Olympic NP), (Quinault Indian Res.)	WF-41
Raft			4		(Quinault Indian Res.)	
Queets			5		Olympic, (Olympic NP), (Quinault Indian Res.)	
Clearwater			5	Spokane	(Quinault Indian Res.)	
Hoh			5	Spokane	(Olympic NP)	
Goodman/Mosquito Crs.			4		(Olympic NP)	
Kalaloch Cr.			4		(Olympic NP)	
Lake Ozette	3				(Olympic NP)	
Ozette R.			4		(Olympic NP)	
Sooes/Waatch			4		(Makah Indian Res.)	
Strait of Juan de Fuca						
Sekiu /Sail			2			
Clallam			4		Olympic	
Pysht /Twin /Deep			2		Olympic	
Lyre	1		4		Olympic(A), (Olympic NP)	WF-39

	Kalaloch Cr.						(Olympic NP)	
	Lake Ozette	3					(Olympic NP)	
	Ozette R.				4		(Olympic NP)	
	Sooes/Waatch				4		(Makah Indian Res.)	
	Strait of Juan de Fuca							
	Sekiu /Sail				2			
	Clallam				4			
	Pysht /Twin /Deep				2		Olympic	
	Lyre	1			4		Olympic	
	Elwha	1			5		Olympic(A), (Olympic NP)	WF-39
	Morse Cr.				2		(Olympic NP)	
	Dungeness				2		Olympic, (Olympic NP)	WF-38
	Sequim Bay				2		Olympic	
	Discovery Bay				1		Olympic	
	Hood Canal							
	Duckabush				2		Olympic, (Olympic NP)	WF-36
	Dosewallips R				5		Olympic, (Olympic NP)	WF-37
	SE Hood Canal				2			

Table V-C-3. (Continued).

Race	Stock	Nehlsen et al.	Higgins et al.	Nickelson et al.	WA Dept. of Fisheries et al.	BLM Districts	National Forests	Key Watersheds
Coho (continued)								
	Dewatto				2			
	NE Hood Canal				2			
	Quilcene/Dabob Bays				2		Olympic	WF-43
	Puget Sound							
	Chambers Cr.	1			5			
	Puyallup				2		Mt. Baker-Snoqualmie, (Puyallup Indian Res.), (Muckleshoot Indian Res.)	WF-23
	Duwamish /Green							
	Newaukum Cr.				2			
	Lake Washington							
	Lk.Wa./Sammamish tribs.				2			
	Cedar				4		(City of Seattle)	
	Snohomish				2	Spokane	Mt. Baker-Snoqualmie	WF-24,25
	Snoqualmie				5	Spokane	Mt. Baker-Snoqualmie	WF-24
	Skykomish				5		Mt. Baker-Snoqualmie	WF-25
	Stillaguamish				2	Spokane	Mt. Baker-Snoqualmie	WF-26-28
	Deer Cr.				4		Mt. Baker-Snoqualmie	WF-27
	Skagit				2	Spokane	Mt. Baker-Snoqualmie, (N. Cascades NP), (Ross Lake NRA)	WF-29,30
	Baker				4		Mt. Baker-Snoqualmie, (N. Cascades NP)	
	N. Puget Sound tribs.				4			
	Nooksack	1			4	Spokane	Mt. Baker-Snoqualmie, (Lummi Indian Res.), (N. Cascades NP)	WF-31,32
	Sumas/Chilliwack							

					(N. Cascades NP),	
Baker			4		(Ross Lake NRA)	
N. Puget Sound tribs.			4		Mt. Baker-Snoqualmie, (N. Cascades NP)	
Nooksack	1		4	Spokane	Mt. Baker-Snoqualmie, (Lummi Indian Res.), (N. Cascades NP)	WF-31,32
Sumas/Chilliwack			4		Mt. Baker-Snoqualmie, (N. Cascades NP)	
Sockeye						
Columbia						
Washington						
Okanogan	3		5	Spokane	Okanogan	
Wenatchee	3		5	Spokane	Wenatchee	WF-15,16,18,19
WA Coast						
Quillayute						
Lk. Pleasant			4		Olympic	WF-40
Ozette R.			2		(Olympic NP)	
Lake Ozette	2				(Olympic NP)	
Puget Sound						
Lake Washington						
Lk. Washington Beach			2			
Lk. Wa./Sammamish tribs.			2			
Cedar			2		(City of Seattle)	
Skagit						
Baker	1		1		Mt. Baker-Snoqualmie, (N. Cascades NP)	
Chum						
Oregon						
Elk	1			Coos Bay	Siskiyou(D)	OF-57
Sixes	1			Coos Bay	Siskiyou(D)	OF-58
Coquille		1		Coos Bay	Siskiyou	OU-59,OB-60-61
Coos	1	1		Coos Bay		OB-62
Umpqua	1			Coos Bay, Roseburg, Medford	Siuslaw(B), Umpqua(B)	OF-63,65,66,87-89; 91,92;OB-64,67,93, 94;OU-86,90
Lower Umpqua & Smith		1		Coos Bay	Siuslaw(B)	OF-63,65,66; OB-64-67
Yachats		1		Salem	Siuslaw(B)	OF-72
Alsea	1	1		Salem	Siuslaw	OU-73
Yaquina	1	5		Salem	Siuslaw	OF-76
Siletz	1	1		Salem	Siuslaw(B)	OB-78
Drift Cr. (Siletz Bay)		1		Salem	Siuslaw(B)	OU-77
Salmon		1		Salem	Siuslaw(B)	
Neskowin		1			Siuslaw(B)	
Sand Cr.		1			Siuslaw(B)	
Nestucca	2	5		Salem	Siuslaw	OF-80-82;OB-79
Little Nestucca		1		Salem	Siuslaw	
Netarts	2					

	[illegible]	1		3		Salem	Siuslaw	OF-76
	Siletz	1		1		Salem	Siuslaw(B)	OB-78
	Drift Cr. (Siletz Bay)			1		Salem	Siuslaw(B)	OU-77
	Salmon			1		Salem	Siuslaw(B)	
	Neskowin			1			Siuslaw(B)	
	Sand Cr.			1			Siuslaw(B)	
	Nestucca	2		5		Salem	Siuslaw	OF-80-82;OB-79
	Little Nestucca			1		Salem	Siuslaw	
	Netarts	2						

Table V-C-3. (Continued).

Race	Stock	Nehlsen et al.	Higgins et al.	Nickelson et al.	WA Dept. of Fisheries et al.	BLM Districts	National Forests	Key Watersheds
Chum (continued)								
	Tillamook Bay	2				Salem, (Tillamook SF)		
	3 sm. Tillamook Bay tribs.			4		(Tillamook SF)		
	Miami			5		Salem, (Tillamook SF)		OB-83
	Kilchis			5		Salem, (Tillamook SF)		OB-84
	Wilson			5		Salem, (Tillamook SF)		OB-85
	Trask			5		Salem		
	Tillamook			5				
	Necanicum			4				
	Columbia					Salem, Prineville, Spokane	Mt. Hood, Gifford Pinchot	OF-118,120;WF-3
	L. Columbia small tribs.	2						
	Washington							
	Hamilton Cr. (fall)				2			
	Grays R. (fall)				2			
	Washougal	1					Gifford Pinchot (B)	
	WA Coast							
	Queets (fall)				4	Spokane	Olympic, (Olympic NP), (Quinault Indian Res.)	
	Hoh (fall)				4	Spokane	(Olympic NP)	
	Quillayute				4		Olympic, (Olympic NP)	WF-40
	Ozette R. (SASSI rating for fall)	1			4		(Olympic NP)	
	Hood Canal (su)	2			1		Olympic, (Olympic NP), (Skokomish Indian Res.)	
	Lower Skokomish (fall)				4		Olympic, (Skokomish Indian Res.)	WF-35
	Strait of Juan de Fuca							
	Elwha (fall)	1			4		Olympic(A), (Olympic NP)	WF-39
	Hoko/Clallam/ Sekiu (fall)				4			
	Lyre (fall)				4		Olympic	
	Dungeness/ E. Strait tribs. (fall)				4		Olympic, (Olympic NP)	WF-38
	Sequim Bay (su)				2		Olympic	
	Discovery Bay (su)				1		Olympic	
	Puget Sound							
	Puyallup/Carbon (fall)				4		Mt. Baker-Snoqualmie(B), (Mt. Rainier NP),	WF-23

Race	Stock	Nehlsen et al.	Higgins et al.	Nickelson et al.	WA Dept. of Fisheries et al.	BLM Districts	National Forests	Key Watersheds
	Sekiu (fall)				4		Olympic	
	Lyre (fall)				4		Olympic, (Olympic NP)	WF-38
	Dungeness/ E. Strait tribs. (fall)				2		Olympic	
	Sequim Bay (su)				1		Olympic	
	Discovery Bay (su)							
	Puget Sound							
	Puyallup/Carbon (fall)				4		Mt. Baker-Snoqualmie(B), (Mt. Rainier NP), (Puyallup Indian Res.), (Muckleshoot Indian Res.)	WF-23
	Hylebos Cr. (fall)				4			
	Henderson Inlet (fall)				4			
	Chambers Cr. (su)	2			0			
	Snohomish				4	Spokane	Mt. Baker-Snoqualmie	WF-24,25
	Snoqualmie (fall)				4		Mt. Baker-Snoqualmie(B)	
	Duwamish-Green	1						
	Skagit				4	Spokane	Mt. Baker-Snoqualmie	
	L. Skagit tribs. (fall)(L)							
	Nooksack				4	Spokane	Mt. Baker-Snoqualmie, (Lummi Indian Res.)	WF-31
	Mainstem/ S. Fk. (fall)				4		Mt. Baker-Snoqualmie(B),	
	+ Sumas/Chilliwack (fall)							
Pink								
	California							
	Russian	1						
	Washington							
	Hood Canal							
	Skokomish	1					Olympic, (Olympic NP), (Skokomish Indian Res.)	WF-35
	Dosewallips				2		Olympic, (Olympic NP)	WF-37
	Strait of Juan de Fuca							
	Elwha	1			1		Olympic(A), (Olympic NP)	WF-39
	Dungeness	2			2		Olympic, (Olympic NP)	WF-38
	Upper Dungeness				1		Olympic, (Olympic NP)	WF-38
	Lower Dungeness						Olympic	WF-38
	Nooksack				4	Spokane	Mt. Baker-Snoqualmie, (Lummi Indian Res.)	WF-32
	N.Fk. & M.Fk. Nooksack							
	S. Fk. Nooksack				4		Mt. Baker-Snoqualmie, (Lummi Indian Res.)	WF-31

Table V-C-3. (Continued).

Race	Stock	Nehlsen et al.	Higgins et al.	Nickelson et al.	WA Dept. of Fisheries et al.	BLM Districts	National Forests	Key Watersheds
Winter Steelhead								
	California							
	Sacramento	1				Ukiah	Shasta-Trinity (A),	
	Oregon							

Race	Stock	Nehlsen et al.	Higgins et al.	Nickelson et al.	WA Dept. of Fisheries et al.	BLM Districts	National Forests	Key Watersheds
Winter Steelhead								
	California							
	Sacramento	1				Ukiah	Shasta-Trinity (A),	
	Oregon							
	Chetco			2		Coos Bay	Siskiyou	OF-46,OB-47
	Pistol			2		Coos Bay	Siskiyou	
	Rogue			5		Coos Bay, Medford	Siskiyou, Rogue River	OF-48-56,98-101; OU-96,97
	Illinois	2		2		Medford	Siskiyou	OF-51-54,56;OU-55
	Sixes			2		Coos Bay	Siskiyou	OF-58
	Coos			2		Coos Bay		OB-62
	Umpqua							
	Smith			2		Coos Bay	Siuslaw	OF-65,66;OB-67
	N. Umpqua			5		Roseburg	Umpqua	OF-87-89,91,92; OU-90
	Siuslaw	3		2		Eugene	Siuslaw	OF-68-70
	Big Cr.	3					Siuslaw	OF-71
	Tenmile Cr.	3		2			Siuslaw	OF-71
	Yachats	3		2		Salem	Siuslaw	OF-72
	Alsea	3		2		Salem	Siuslaw	OU-73;OB-74,75
	Yaquina	3				Salem	Siuslaw	OF-76
	Siletz	3		2		Salem	Siuslaw	OB-78
	Salmon	3		2		Salem	Siuslaw	
	Nestucca	3		2		Salem	Siuslaw	OF-80-82;OB-79
	Tillamook Bay	3				Salem, (Tillamook SF)		
	Miami			2		(Tillamook SF)		
	Kilchis			2		Salem, (Tillamook SF)		OB-83
	Wilson			2		Salem, (Tillamook SF)		OB-84
	Trask			2		Salem, (Tillamook SF)		OB-85
	Nehalem			2		(Tillamook SF), (Clatsop SF)		
	Salmonberry			2		(Tillamook SF), (Clatsop SF)		
	Necanicum			1				
	Columbia							
	Willamette							
	Calapooia	3				Eugene	Willamette	
	Clackamas	2				Salem	Mt. Hood	OF-121-125; OU-126
	Hood	1				Prineville	Mt. Hood	OF-119
	Fifteenmile Cr.	2				Prineville	Mt. Hood	OF-118
	L. Columbia small tribs. below Bonneville Dam	2				Salem, Spokane	Mt. Hood, Gifford Pinchot	
	L. Columbia small tribs. above Bonneville Dam	1				Spokane, Prineville	Mt. Hood, Gifford Pinchot	OF-118,120;WF-3
	Washington							
	Mill Cr.				2			
	Abernathy Cr.				2			

	Hood	1				Prineville	Mt. Hood	OF-119
	Fifteenmile Cr.	2				Prineville	Mt. Hood	OF-118
	L. Columbia small tribs. below Bonneville Dam	2				Salem, Spokane	Mt. Hood, Gifford Pinchot	
	L. Columbia small tribs. above Bonneville Dam	1				Spokane, Prineville	Mt. Hood, Gifford Pinchot	OF-118,120;WF-3
	Washington							
	Mill Cr.				2			
	Abernathy Cr.				2			
	Germany Cr.				2			
	Grays R.	3			2			
	Skamokawa Cr.				4			
	Elochoman	3			2			
	Cowlitz	2			2	Spokane	Gifford Pinchot (A)(C)	WF-7-10
	Toutle	3					Gifford Pinchot	
	Mainstem/N.Fk. Toutle				2		Gifford Pinchot, (Mt. St. Helens NVM)	
	Green				2		Gifford Pinchot, (Mt. St. Helens NVM)	
	Coweeman	3			2			
	Kalama	3			5		Gifford Pinchot(B), (Mt. St. Helens NVM)	
	Lewis	3					Gifford Pinchot (A)	WF-2,6
	E. Fk. Lewis				2		Gifford Pinchot	WF-2
	Mainstem/N.Fk. Lewis				2	Spokane	Gifford Pinchot(A), (Mt. St. Helens NVM)	WF-6

Table V-C-3. (Continued).

Race	Stock	Nehlsen et al.	Higgins et al.	Nickelson et al.	WA Dept. of Fisheries et al.	BLM Districts	National Forests	Key Watersheds
Winter Steelhead (continued)								
	Salmon Cr.				2			
	Washougal	2					Gifford Pinchot (B)	
	Mainstem Washougal				4		Gifford Pinchot (B)	
	W.Fk. of N.Fk. Washougal				4	Spokane	Gifford Pinchot(B)	
	Wind	1			4		Gifford Pinchot	WF-1
	White Salmon	1			2		Gifford Pinchot(B)	WF-5
	Hamilton Cr.				4			
	WA Coast							
	Willapa Bay							
	North/Smith Cr.				4			
	Palix				4			
	Nemah				4			
	Bear				4			
	Grays Harbor							
	Chehalis							
	Skookumchuck/ Newaukum				2			
	Satsop				2		Olympic	WF-34
	S. Harbor				4			

Nemah		4			
Bear		4			
Grays Harbor					
Chehalis					
Skookumchuck/ Newaukum		2			
Satsop		2		Olympic	WF-34
S. Harbor		4			
Copalis		4			
Raft		4		(Quinault Indian Res.)	
Kalaloch Cr.		4		(Olympic NP)	
Mosquito Cr.		4		(Olympic NP)	
Goodman Cr.		4		(Olympic NP)	
Ozette		4		(Olympic NP)	
Sooes/Waatch		4		(Makah Indian Res.)	
Strait of Juan de Fuca					
Sail		4			
Sekiu		4			
Clallam		4			
Lyre		4		Olympic, (Olympic NP)	
Salt Cr./Independents		4		(Olympic NP)	
Elwha		2		Olympic(A), (Olympic NP)	WF-39
Morse Cr./Independents		2			
Dungeness		2		Olympic, (Olympic NP)	WF-38
Sequim Bay		4		Olympic	
Discovery Bay		2		Olympic	
Hood Canal					
Dewatto	1	2			
Tahuya	2	2			
Union		4			
Skokomish	3	2		Olympic, (Skokomish Indian Res.)	WF-35
Hamma-Hamma		4		Olympic	
Duckabush		2		Olympic, (Olympic NP)	WF-36
Dosewallips		2		Olympic, (Olympic NP)	WF-37
Quilcene/Dabob Bays		4		Olympic	WF-43
Puget Sound					
E. Kitsap		4			
Case/Carr Inlets		4			
Hammersley Inlet		4			
Totten Inlet		4			
Eld Inlet		4			
Lake Washington	2	2		Mt. Baker-Snoqualmie	
Skagit					
Cascade		4	Spokane	Mt. Baker-Snoqualmie, (N. Cascades NP)	
Samish	3	2			
Dakota Cr.		4			
Nooksack	3	4	Spokane	Mt. Baker-Snoqualmie, (N. Cascades NP), (Lummi Indian Res.)	WF-31,32
N. Fk. Nooksack		4		Mt. Baker-Snoqualmie,	WF-32

Race	Stock	Nehlsen et al.	Higgins et al.	Nickelson et al.	WA Dept. of Fisheries et al.	BLM Districts	National Forests	Key Watersheds
	Skagit							
	Cascade				4	Spokane	Mt. Baker-Snoqualmie, (N. Cascades NP)	
	Samish	3			2			
	Dakota Cr.				4			
	Nooksack	3			4	Spokane	Mt. Baker-Snoqualmie, (N. Cascades NP), (Lummi Indian Res.)	WF-31,32
	N. Fk. Nooksack				4		Mt. Baker-Snoqualmie, (N. Cascades NP), (Lummi Indian Res.)	WF-32
	S. Fk. Nooksack				4		Mt. Baker-Snoqualmie, (Lummi Indian Res.)	WF-31
	M. Fk. Nooksack				4	Spokane	Mt. Baker-Snoqualmie, (N. Cascades NP), (Lummi Indian Res.)	

Table V-C-3. (Continued).

Race	Stock	Nehlsen et al.	Higgins et al.	Nickelson et al.	WA Dept. of Fisheries et al.	BLM Districts	National Forests	Key Watersheds
Summer Steelhead								
	California							
	Eel	2				Ukiah	Mendocino, Six Rivers, (Round Valley Indian Res.)	CF-140-142,147
	Van Duzen		1			Ukiah	Six Rivers(A)	
	M. Fk. Eel		3			Ukiah	Mendocino, Six Rivers	CF-140-142
	N. Fk. Eel		1			Ukiah	Six Rivers, Mendocino	CF-147
	Mad	1	1				Six Rivers	CF-148
	Redwood Cr.	1	1			Ukiah	Six Rivers(B)	
	Klamath	2					Klamath, Six Rivers, Shasta-Trinity, (Hoopa Indian Res.)	CF-143-146,149-154, CF-156-161
	Middle Klamath tribs. (F)		1			Ukiah	Six Rivers, Klamath	CF-149,150, CF-158-160
	Salmon		1			Ukiah	Klamath	CF-156,157
	Trinity							
	S. Fk. Trinity		1				Shasta-Trinity, Six Rivers	CF-145,153
	New River		2				Shasta-Trinity	CF-146
	Upper Trinity		1				Shasta-Trinity	CF-143,144
	N. Fk. Tinity		2			Ukiah	Shasta-Trinity	CF-143
	Smith	1					Six Rivers, Siskiyou	CF-155;OF-44
	Oregon							
	Rogue	2		2		Coos Bay, Medford	Siskiyou, Rogue	OF-48-54,56,98-101; OU-55,96,97
	Siletz	2		2		Salem	Siuslaw	OB-78
	Columbia							
	Hood	2				Prineville	Mt. Hood	OF-119
	L. Columbia small tribs. above Bonneville Dam	1				Spokane, Prineville	Mt. Hood, Gifford Pinchot	OF-118,120;WF-3
	Washington							
	Cowlitz	1				Spokane	Gifford Pinchot(A)(C)	WF-9

Rogue	2	2		Coos Bay, Medford	Siskiyou, Rogue	OF-48-54,56,98-101, OU-55,96,97
Siletz	2	2		Salem	Siuslaw	OB-78
Columbia						
Hood	2			Prineville	Mt. Hood	OF-119
L. Columbia small tribs. above Bonneville Dam	1			Spokane, Prineville	Mt. Hood, Gifford Pinchot	OF-118,120;WF-3
Washington						
Cowlitz	1			Spokane	Gifford Pinchot(A)(C)	WF-9
Kalama			2		Gifford Pinchot(B), (Mt. St. Helens NVM)	
Lewis						
N. Fk. Lewis	1		2		Gifford Pinchot(A), (Mt. St. Helens NVM)	
E. Fk. Lewis	3		4	Spokane	Gifford Pinchot	WF-2
Washougal	1			Spokane	Gifford Pinchot(B)	
Mainstem Washougal			4		Gifford Pinchot(B)	
W.Fk. of N.Fk. Washougal			4	Spokane	Gifford Pinchot(B)	
Rock Cr.			4	Spokane	Gifford Pinchot(B)	
Wind	2		2		Gifford Pinchot	WF-1
Panther Cr.			2		Gifford Pinchot	WF-1
Trout Cr.			2		Gifford Pinchot	WF-1
White Salmon	1		2	Spokane	Gifford Pinchot(B)	WF-5
Yakima			2	Spokane	Wenatchee	WF-11-14
Wenatchee	3		2	Spokane	Wenatchee	WF-15,16,18
Entiat	1		2	Spokane	Wenatchee	WF-19
Methow/Okanogan			2	Spokane	Okanogan	WF-20-22
Methow	1			Spokane	Okanogan	WF-20-22
Okanogan	1			Spokane	Okanogan	
WA Coast						
Grays Harbor						
Chehalis			4	Spokane, (Capitol SF)	Olympic	WF-33,34
Humptulips			4		Olympic	WF-41
Quinault			4		Olympic, (Olympic NP), (Quinault Indian Res.)	
Queets						
Clearwater			4	Spokane	(Quinault Indian Res.)	
Hoh			4	Spokane	(Olympic NP)	
Quillayute						
Calawah			4		Olympic, (Olympic NP)	
Bogachiel			4		Olympic, (Olympic NP)	
Sol Duc			4		Olympic, (Olympic NP)	WF-40
Strait of Juan de Fuca						
Elwha			2		Olympic(A), (Olympic NP)	WF-39
Dungeness			2		Olympic, (Olympic NP)	WF-38
Hood Canal						
Dosewallips			4		Olympic, (Olympic NP)	WF-37
Duckabush			4		Olympic, (Olympic NP)	WF-36

	Elwha				2		Olympic(A), (Olympic NP)	WF-39
	Dungeness				2		Olympic, (Olympic NP)	WF-38
	Hood Canal							
	Dosewallips				4		Olympic, (Olympic NP)	WF-37
	Duckabush				4		Olympic, (Olympic NP)	WF-36

Table V-C-3. (Continued).

Race	Stock	Nehlsen et al.	Higgins et al.	Nickelson et al.	WA Dept. of Fisheries et al.	BLM Districts	National Forests	Key Watersheds
Summer Steelhead (continued)								
	Skokomish				4		Olympic, (Olympic NP), (Skokomish Indian Res.)	WF-35
	Snohomish							
	Snoqualmie							
	Tolt	1			2		Mt. Baker-Snoqualmie	
	Skykomish							
	N. Fk. Skykomish				4		Mt. Baker-Snoqualmie	WF-25
	Stillaguamish/Deer Cr.	1				Spokane	Mt. Baker-Snoqualmie	WF-26-28
	S. Fk. Stillaguamish				4		Mt. Baker-Snoqualmie	WF-26
	Canyon Cr.				4		Mt. Baker-Snoqualmie	WF-26
	Deer Cr.				1		Mt. Baker-Snoqualmie	WF-27
	Skagit							
	Cascade				4	Spokane	Mt. Baker-Snoqualmie, (N. Cascades NP)	
	Sauk				4	Spokane	Mt. Baker-Snoqualmie	WF-29,30
	Finney Cr.				4		Mt. Baker-Snoqualmie	
	Nooksack							
	S. Fk. Nooksack	2			4	Spokane	Mt. Baker-Snoqualmie, (Lummi Indian Res.)	WF-31
Sea-run Cutthroat Trout								
	California							
	CA coastal streams	2				Ukiah	Six Rivers, Trinity, Mendocino	CF-155;CB-162
	Lower Eel (H)		3			Ukiah, (Humboldt Redwoods SP)	Six Rivers	
	Lower Klamath		3			Ukiah	Six Rivers, (Hoopa Indian Res.)	CF-151
	Mad		3			Ukiah	Six Rivers	CF-148
	Wilson Cr.		3				(Redwood NP)	
	Oregon							
	OR coastal streams	2				Salem, Coos Bay,	Siskiyou, Siuslaw	OF-44,46,57,58,63, 65,66,68-72,76, 80-82;OB-47,60,61, 62,64,67,74,75,78, 79,83-85;OU-59, 73,77
	Columbia							
	Hood	1					Mt. Hood	OF-119
	L.Columbia small tribs.	2				Salem, Spokane	Mt. Hood, Gifford Pinchot	OF-118,120;WF-3

				80-82;OB-47,60,61, 62,64,67,74,75,78, 79,83-85;OU-59, 73,77
Columbia				
Hood	1		Mt. Hood	OF-119
L.Columbia small tribs. below Bonneville Dam	2	Salem, Spokane	Mt. Hood, Gifford Pinchot	OF-118,120;WF-3
Washington				
Elochoman	3			
Cowlitz	3		Gifford Pinchot(A)	WF-7-10
Toutle	3		Gifford Pinchot, (Mt. St. Helens NVM)	
Coweeman	3			
Kalama	3		Gifford Pinchot(B), (Mt. St. Helens NVM)	
Washougal	3	Spokane	Gifford Pinchot(B)	
Rock Cr.	1	Spokane	Gifford Pinchot(B)	
WA coastal & Puget Sound tribs. (except tribs. to Grays Harbor & Hood Canal)	3	Spokane	Olympic, Mount Baker-Snoqualmie, (Olympic NP)	WF-38-40
Grays Harbor & Hood Canal tribs.	3	Spokane	Olympic, (Olympic NP)	WF-35-37,43

Footnotes

a No anadromous fish run on Forest Service land due to dam blocking access.
b Forest Service or Bureau of Land Management manage headwaters above the extent of anadromy
c Anadromous fish access to Forest Service land blocked by dam but trucking of anadromous fish currently occurring.
d Possibly extinct.
e Stock is listed federally as threatened and by the state of California as endangered.
f Dillon, Elk, Indian, Clear, Red Cap, and Bluff Creeks (Higgins et al.).
g Below Weitchpec (Higgins et al.).
h Below N.Fk. Eel R. (Higgins et al.).
i Below Illinois R. (Oregon Department of Fish &Wildlife, Provisional list of wild fish populations.)
j Illinois R. to Gold Ray dam (Oregon Department of Fish and Wildlife, Provisional list of wild fish populations.)
k Above Gold Ray dam (Oregon Department of Fish and Wildlife, Provisional list of wild fish populations.)
l Below Sauk R.

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Appendix D

Status of Water Quality

Every two years each state reviews all available information on water quality as part of a statewide water quality assessment. This assessment is required by section 305(b) of the Clean Water Act.

The 305(b) report assesses state waters (estuaries, lakes, rivers streams, wetlands) to determine whether the quality is high enough to support the beneficial uses of each individual water body. Beneficial uses include salmon (and other fish) migration, spawning, rearing and harvest, wildlife habitat, provision of domestic water supplies, and other uses identified in the water quality standards for each state. The assessments also identify the specific problems or pollutants which affect beneficial uses and the source of the pollutant. These reports assess both point and nonpoint pollutant sources.

We are becoming increasingly aware that many water quality problems are attributable to nonpoint sources (NPS) of pollution. Principal sources include stormwater, agriculture, forestry, construction, recreation, transportation, municipal and industrial activities. Major effects include temperature changes, excess nutrients, bacterial contamination, sedimentation, lowered dissolved oxygen, flow alteration and habitat alteration. States also perform statewide assessments of nonpoint source pollution as required by section 319 of the Clean Water Act. In Region 10 of EPA (Alaska, Oregon, Washington and Idaho) 60-70 percent of pollutants originate from NPS (Edwards et al. 1992).

In rural areas, including forest lands, nonpoint sources are the major pollutant problem. Problems include erosion and sedimentation, elimination of riparian vegetation which directly alters wildlife habitat and leads to temperature increases in rivers and streams, and other major habitat changes.

Section 303 of the Clean Water Act directs the states to adopt water quality standards and criteria as necessary to protect designated beneficial uses for the waters of the state. The designated agencies in the states develop and apply water quality standards and criteria for the state's waters in order to protect identified beneficial uses as delineated in states administrative rules (CWA ~ 303(c)(2), 40 CFR ~ 131.3). Criteria may be constituent concentrations, levels, or narrative statements representing water quality supporting a particular use.

Where application of current best management practices or technology based controls are not sufficient to achieve designated water quality standards, the water body is classified as water quality limited. Under section 303 (d) of the Clean Water Act states must list those waters which are water quality limited and establish total maximum daily loads (TMDL) for these waters.

EPA has oversight responsibility for state implementation of this requirement and in the absence of state action is required to prepare TMDLs. To date, 159 water bodies in Oregon, Washington and Idaho have been included on the 303(d) lists.

Development of a TMDL consists of two key steps: 1) determination of a water body's loading capacity for a pollutant of concern, and 2) allocation of the available loading capacity to point and nonpoint sources of pollution, after consideration of any natural inputs. A TMDL must also include a margin of safety to account for any uncertainty due to a lack of information.

TMDLs fit very well into the context of watershed analysis, planning and management. They provide a basis to evaluate problems in a watershed, define the management targets for the stressors, establish implementation schedules, and establish monitoring requirements. Development of a TMDL requires the same processes p.rop~sed in the watershed analysis and currently applied cumulative effects analyses; it thus appears that TMDL requirements could be met by the interdisciplinary analytic approaches defined in the watershed analysis.

Status of water quality is summarized below for California, Washington and Oregon, the states where northern spotted owl habitat occurs. However, the assessment and summary includes information statewide since the entire state has relevancy to stocks of anadromous fish which are endangered or at risk. Data availability and accessibility varies greatly for each state. Where possible, information is provided to indicate water quality conditions on federal lands compared to state and private lands with emphasis on conditions within the range of the northern spotted owl and identified fish stocks endangered or at risk.

It is apparent that water quality problems from land use activities are severe on all ownerships. It is also clear that comprehensive improvement in support of beneficial uses such as fisheries habitat will require protection and restoration in complete watersheds, not limited by ownership boundaries.

Oregon

Oregon includes over 100,000 miles of rivers and streams. Of these, the Oregon Department of Environmental Quality has evaluated about 24,000 miles. Rivers have been evaluated based on water quality standards and categorized on the basis of whether they currently support designated beneficial uses. Estimates made in 1992 identify 12,652 miles as fully supporting or unknown, 8702 as partially supporting, and 7755 as not supporting beneficial uses (Oregon Department of Environmental Quality 1992). This data includes impairment from both point and nonpoint pollutants sources. For over 50 stream segments>the state has determined that technology based controls will not be sufficient to meet water quality standards. These have been placed on the state 303(d) list.

Assessment has also been made specifically for nonpoint sources both in terms of pollutant source and cause of water quality impairment. Of 27,700 miles assessed, approximately 15,400 miles were reported to be either severely or moderately impacted by nonpoint source pollution (Edwards et al. 1992). Over 20 percent of these waters are affected by range activities and between 15 and 20 percent are affected by agriculture and a similar amount are affected by silviculture. Between 10 and 20 percent of the cause of water quality impairment is from habitat alteration, flow alteration, temperature, and siltation all of which are problems associated with forest practices.

Activities contributing to nonpoint source have also been estimated for each basin in the state. Range, agriculture and forestry activities produce the greatest impacts in terms of miles of river affected (Table V-D-1).

Oregon Stream Conditions on Federal Lands

Table V-D-2 is a summary of the known conditions of streams on federal lands~ in Oregon. Based on a total of 15,200 stream miles surveyed in the state of Oregon, 30 percent or 4,600 miles are moderately to severely impaired on federal lands. On federal lands within the range of the spotted owl, 25 percent or 1,900 miles o~f streams are moderately to severely impaired on federal lands.

Table V-D-3 is a summary of water quality parameters causing stream impairment on federal lands in the state of Oregon. The parameter reported as being the leading cause of impairment is sediment, with over 3532 stream miles impaired on federal land statewide. In the range of the spotted owl, 1413 miles are impaired due to sediment and 3726 miles on private land.

Temperature is an important cause of impairment on 7342 miles statewide. On federal lands 3071 miles are impaired due to temperature. On federal lands in the range of the spotted owl 973.1 miles are impaired and 2545 miles are impaired on private lands with owl habitat.

Turbidity, erosion and structure (bank stability) problems result in 7846 miles of impaired streams on federal land, with 1802 miles in the range of the owl. Of lesser importance to water quality impairment are nutrients and low dissolved oxygen.

Washington

The most recent statewide water quality assessment for Washington was completed in 1992. Individual assessments were conducted for 798 water bodies including lakes, estuaries rivers and streams. Of the over 40,000 miles of rivers and streams in Washington, 5,600 segments were evaluated representing 14 percent of all rivers and streams in the state (Washington Department of Ecology 1992).

Results of the 1992 assessment indicated that over 75 percent of water quality impairment in waters evaluated was related to nonpoint sources. Major NPS categories affecting surface water quality and aquatic resources in Washington include agriculture, forest practices, stormwater, on-site sewage systems, surface mining, and boats and marinas.

In rivers and streams, bacteria, and thermal changes have the greatest impact on the water quality of the state's rivers and streams. Other substances having moderate to high impacts include metals, siltation, suspended solids, organic enrichment, low dissolved oxygen, and nutrients. Agriculture, particularly irrigated crop production and animal keeping, has a greater impact on rivers and streams than any of the other major nonpoint source categories. Based on current analysis, impacts from forest practices and rangeland activities are moderately low; however, these percentages reflect the relative paucity of assessment information for these sources statewide, and probably underestimate the extent of their influences, (Edwards et al. 1992).

Based on the 1992 statewide assessment over 3,000 miles of rivers and streams in Washington did not fully support designated beneficial uses (Table V-D-4) water bodies, the state has determined that technology based controls will not be sufficient to meet water quality standards.

It is estimated that about 470 miles of rivers and streams were impaired by silviculture activities and about 1210 total miles of streams were impaired on federal lands being evaluated in this report. Of the 1210 miles, 1094 were within the range of the northern spotted owl.

California

Within the State of California, the range of Northern Spotted -Owl lies in the North Coastal and the Klamath Basins, 13 hydrologic Units that are assessed for water quality by the California North Coast Regional Water Quality Control Board. In those 13 Hydrologic Areas the North Coast Board has evaluated the attainment of Clean Water Act goals of aquatic habitat and contact recreation in 174 river and stream waterbodies. Water quality in approximately 88 of those waterbodies has been evaluated as being impaired. In four of the river or stream waterbodies within the range of the Northern Spotted Owl, Clean Water Act Regulations require that Total Maximum Daily Loads (TMDL) calculations for point and nonpoint sources of pollution be produced. Of the 24 waterbodies listed, 13 have nonpoint source pollution problems directly or indirectly related to present or historical logging practices.

U.S. Forest Service Lands

Forest management plans prepared by the U.S. Forest Service contain Best Management Practices including Standards and Guidelines and mitigating measures for protecting and enhancing water quality and beneficial uses affected by forestry practices. The Washington State Department of Ecology and the Forest Service cooperate in support of a full time coordinator to facilitate water quality management on Forest Service lands in Washington. An inventory has been completed of available data, water quality studies, and program evaluation has been completed. When forest plans are finalized, water quality standards, mitigation measures, and monitoring will be included in a statewide document with specified reporting and information sharing requirements. Requirements in the statewide document should be consistent with the options proposed in this report.

Table V-D-1. Suspected nonpoint sources of water quality problems in rivers where beneficial uses are not fully supported - Summary by basin of river miles affected by each source (1988 assessment).

River miles impacted by more than one source are counted separately for each source.

Basin	Nonpoint source: Agriculture	Range	Forestry	Storm water Combined Sewers	Construction	Transport	Mining	Recreation	Natural	Other
North coast/L.Columbia	475	315	615	135	185	325	295	425	480	0
Mid coast	350	195	545	10	85	20	90	295	115	0
Umpqua	365	415	820	110	30	375	185	135	270	0
South Coast	430	180	625	40	15	75	135	15	215	0
Rogue	615	250	545	225	270	165	300	215	637	0
Willamette	720	495	585	680	485	400	420	1,225	480	5
Sandy	5	5	115	5	10	0	0	120	55	0
Hood	120	100	155	10	0	40	0	100	40	0
Deschutes	705	970	520	210	190	65	110	675	205	0
John Day	1,120	1,315	1,035	5	0	0	125	685	985	0
Umatilla/Walla Walla	620	670	140	70	50	40	45	85	75	0
Grande Ronde	390	805	680	55	60	340	135	540	70	5
Powder/Burnt	235	890	340	30	5	125	285	265	55	0
Malheur	450	630	80	70	35	0	10	270	60	0
Owyhee	230	295	30	0	0	0	145	165	35	0
Malheur Lake	160	820	270	0	0	135	0	540	75	0
Goose & Summer Lakes	145	445	145	0	0	10	0	10	90	0
Klamath	470	510	335	20	0	0	0	210	290	0
Total	7,605	9,305	7,580	1,675	1,420	2,115	2,280	6,005	4,232	10

Note: The information in this table was based on DEQ's nonpoint source assessment which was completed in 1988. The assessment is a data base which contains monitored data (based on actual sampling, including the results of DEQ's ambient monitoring) and evaluated data (based on a combination of data, observation, and professional judgment). The evaluated data were largely provided by other agencies and have not yet been verified by DEQ. The mileage numbers should therefore be treated as estimates. Updates of the assessment are planned. In this assessment, most of the information received was for major first order streams where problems existed. If no problems were reported for a particular stream segment, that segment was grouped with the "fully supported" segments. Streams with "moderate" water quality problems were classified as "partially supported." Streams with "severe" water quality problems were classified as "not supported."

From: Oregon Department of Environmental Quality Nonpoint Source Statewide Management Program for Oregon April 1991.

Table V-D-2. State of Oregon stream condition on federal lands.

	Statewide			Spotted owl range		
	Federal ownership	Miles	(%)	Federal ownership	Miles	(%)

Table V-D-2. State of Oregon stream condition on federal lands.

	Statewide			Spotted owl range		
	Federal ownership	Miles	(%)	Federal ownership	Miles	(%)
Severe Impairment	BLM	800	(14.7)	BLM	200	(7.5)
	FS	800	(13.4)	FS	300	(14.0)
	Non federal	4,100	(71.8)	Non federal	1,800	(78.5)
Sub-total:		5,700	100		2,300	100
Moderate Impairment	BLM	1,100	(13.4)	BLM	400	(8.5)
	FS	1,900	(21.3)	FS	1,000	(22.2)
	Non federal	5,700	(65.3)	Non federal	3,300	(69.3)
Sub-total:		8,700	100		4,700	100
Other	BLM	100	(10.0)	BLM	100	(11.6)
	FS	200	(26.3)	FS	100	(21.0)
	Non federal	500	(63.7)	Non federal	400	(67.4)
Sub-total:		800	100		600	100
Total:		15,200			7,600	

From: 1988 Oregon statewide assessment of nonpoint sources of water pollution.

Table V-D-3. Stream miles impaired on Federal lands in Oregon by water quality parameter.

	Lands statewide			Federal land owl range		
Water quality parameter	BLM	FS	Non federal	BLM	FS	Non federal
1. Temperature	1,600	1,500	4,300	300	600	2,500
2. Turbidity	1,300	1,500	6,400	300	800	3,000
3. Sedimentation	1,500	2,000	7,400	400	1,000	3,800
4. Erosion	1,400	1,500	6,700	200	500	2,600
5. Structure	1,000	1,000	3,600	300	500	1,500
6. Nutrients	300	200	2,800	46	60	1,400

1. Temperature	1,600	1,500	4,300	300	600	2,500
2. Turbidity	1,300	1,500	6,400	300	800	3,000
3. Sedimentation	1,500	2,000	7,400	400	1,000	3,800
4. Erosion	1,400	1,500	6,700	200	500	2,600
5. Structure	1,000	1,000	3,600	300	500	1,500
6. Nutrients	300	200	2,800	46	60	1,400
7. Low DO	200	200	1,900	26	15	700
Total:	7,300	7,200	33,100	1,572	3,475	15,500

From: 1988 Oregon statewide assessment of nonpoint sources of water pollution

Table V-D-4. Total length of rivers not fully supporting designated uses affected by various source categories.

RIVER (all size units in stream miles)		
Source categories	Major impact	Moderate/minor impact
Point sources - overall	303.80	1,127.82
Industrial point sources	285.20	842.31
Municipal point sources	18.60	592.06
Nonpoint sources - overall	1,163.48	3,215.35
Nonpoint source - unspecified	101.22	3.08
Combined sewer overflow	0.00	51.41
Agriculture - overall	213.57	1,837.76
Agriculture - unspecified	88.49	995.79
Nonirrigated crop production	0.00	4.30
Irrigated crop production	114.23	490.15
Specialty crop production	0.00	65.31
Pasture land	0.00	757.12
Range land	0.00	68.21
Feedlots - all types	0.00	89.70
Aquaculture	0.00	30.41
Animal holding/management areas	10.85	636.78
Manure lagoons	0.00	75.62

Feedlots - all types	0.00	89.70
Aquaculture	0.00	30.41
Animal holding/management areas	10.85	636.78
Manure lagoons	0.00	75.62
Silviculture - overall	101.80	472.84
Silviculture - unspecified	67.50	235.84
Harvesting, restoration, residue management	1.80	247.50
Forest management	2.40	150.50
Road construction/maintenance	30.10	221.20
Construction - overall	0.00	294.81
Construction - unspecified	0.00	0.00
Highway/road/bridge	0.00	21.41
Land development	0.00	287.51
Urban runoff	12.86	521.16

From Washington State Department of Ecology 1992 statewide water habitat assessment

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Appendix E

Definition and Relation of Wetlands to Riparian Areas

Wetlands and riparian areas are often treated as synonymous in general discussions, and indeed their position in the landscape, interposed between aquatic and upland ecosystems, is frequently similar and overlapping. However, many riparian areas do not meet currently accepted technical criteria for wetlands nor are they inventoried as wetlands under projects such as the National Wetland Inventory of the Fish and Wildlife Service.

Wetlands -- whether defined for regulatory jurisdiction (e.g., Clean Water Act regulations) or for technical analysis (e.g., inventory or functional assessment) -- are characterized by a combination of hydrology, soils, and vegetation characteristics, Of greatest importance in development of wetland habitats is the presence of surface water or saturated soils for sufficient duration to promote development of plant communities that have a dominance of species adapted to survive and grow under extended periods of soil anaerobiosis.

Formal definition for implementing section 404 of the Clean Water Act is as follows:

> The term wetlands means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas (US Environmental Protection Agency).

Detailed technical methods have been developed to assist in identification of wetlands in the field that meet the above definition. Currently, the field manual being used for implementing the Clean Water Act is the "1987 Corps Manual (U.S. Army Corps of Engineers 1987).

For purposes of conducting the National Wetland Inventory, the Fish and Wildlife Service has broadly defined both vegetated and nonvegetated wetlands as follows:

> Wetlands are lands transitiorml between terrestrial and aquatic systems where the water table is usually at

> or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year (Cowardin et al 1979).

This definition is accompanied by a detailed hierarchial classification comprising five systems: marine, estuarine, riverine, lacustrine, and palustrine. All of the vegetated wetlands within the range of the northern spotted owl are within the palustrine system.

Wetland habitats circumscribed by the above definitions overlap with riparian zones. Most typically, and particularly in forested landscapes, the riparian zone is defined by its spatial relation to adjacent streams or rivers. However, riparian zones are also commonly considered to be lands integrally related to other aquatic habitats such as lakes, reservoirs, intermittent streams, springs, seeps, and wetlands.

Because of such conceptual and definitional vagaries, we get the spatial overlap between wetlands and riparian zones. This then results in only a portion of the riparian zone associated with rivers and streams being considered wetlands. The extent of that portion will depend on the specifics of hydrologic, vegetation, a~d sail features. The functions of the wetland portion may also be distinct from the nonwetlands. For example, wetlands may provide habitat for specialized plant species or reproductive habitat for amphibians or other organisms that would not be provided by riparian areas.

Wetlands in Forest Ecosystems

While most wetlands within forested ecosystems will be spatially and functionally associated with rivers and streams, so me occur more or less in isolation. Isolated wetlands will often be small but frequently have unique characteristics including habitat for specialized plants and animals. Peat systems such as fens and bogs are in this category. In the Pacific Northwest these habitats are typically over 10,000 years of age and are often referred to as the "old growth wetlands. Specially adapted plant species such as cranberry (Vaccinium oxycoccus'), sphagnum mosses and others occur here along with rare and sensitive species such as Gentiana spp.

Most of the wetlands within the forest will be in the riparian zones and the ecological functions will be integral to the nonwetland portion of the riparian zone and to the adjacent river or stream. For this reason, management alternatives in this report consider riparian wetlands within the context of the overall watershed management objectives rather than as discrete landscape entities.

Wetland Functions

Functions of wetlands and riparian areas exhibit considerable overlap, particularly in forested ecosystems are discussed in detail in other sections of this report discusses those functions and processes that relate to maintenance of high quality river and stream habitats. This s'ection focuses on the functions generally attributed to wetlands, with emphasis on water quality, habitat, and biodiversity. This is followed by discussion of specific functions of Northwest forested wetlands and riparian zones.

The National Research Council (1992) has summarized wetland functions under 15 categories:

Flood conveyance -- Riverine wetlands and adjacent floodplain lands often form natural floodways that convey floodwaters from upstream to downstream areas.

Protection from storm waves and erosion -- Coastal wetlands and inland wetlands adjoining larger lakes and rivers reduce the impact of storm tides and waves before they reach upland areas.

Flood storage -- Inland wetlands may store water during floods and slowly release it to downstream areas, lowering flood peaks.

Sediment control -- Wetlands reduce flood flows and the velocity of floodwaters, reducing erosion and causing floodwaters to release sediment.

Habitat for fish and wildlife -- Wetlands are important spawning and nursery areas and provide sources of nutrients for commercial and recreational fin and shellfish industries particularly in coastal areas.

Habitat for waterfowl and other wildlife -- Both coastal and inland wetlands provide essential breeding, nesting, feeding, and refuge habitats for many forms of waterfowl, other birds, mammals, and reptiles.

Habitat for rare arid endangered species -- Although wetlands constitute only about 5 percent of the nation's lands, almost 35 percent of all rare and endangered animal species either are in wetland areas or are dependent on them.

Recreation -- Wetlands serve as recreation for fishing, hunting, and observing wildlife.

Source of water supply -- Wetlands are becoming increasingly important as sources of ground and surface water because of the growth of urban centers and dwindling ground and surface water supplies.

Food production -- Because of their high natural productivity, both tidal and inland wetlands have unrealized food production potential for harvesting of marsh vegetation and aquaculture.

Preservation of historic, archaeological values -- Some wetlands are of archaeological interest. Indian settlements in coastal and inland wetlands served as sources of fish and shellfish.

Education and research -- Tidal, coastal, and inland wetlands provide educational opportunities for nature observation and scientific study.

Source of open space and contribution to aesthetic values -- Both tidal and inland wetland are areas of great diversity and beauty and provide open space for recreational and visual enjoyment.

Water quality improvement -- Wetlands contribute to improving water quality by removing excess nut+ie.nts, sediments, and chemical contaminants. They are sometimes used in tertiary treatment of wastewater.

Investigations of these 15 functions have intensified in the past decade. A comprehensive literature review completed by Adamus et al. (1991) references over 1,200 reports and publications related tti wetlands. Functions specific to wetlands of the Pacific Region have been summarized by Zedler, Huffman and Josselyn (1985) in cooperation with the National Wetlands Technical Council.

Water Quality Improvement

Water quality benefits of wetlands and riparian zones accrue to adjacent aquatic habitats. Sediments, inorganic nutrients, and organic toxicants are removed from water that flows across wetlands.

Mitsch and Gosselink (1986) summarize the attributes of wetlands and riparian zones that are important in water quality protection include:

1. As water enters wetlands, velocity decreases and sediments and chemicals attached to sediments drop out.

2. Chemical processes result in precipitation and removal of chemicals from water.

3. High production in wetlands can result in uptake of nutrients and eventual burial of the nutrients when plants

die.

4. Chemicals are decomposed in wetland sediments.

5. A high amount of contact exists between sediments and water in wetlands, which leads to removal of pollutants from the water.

6. Accumulation of peat in many wetlands can cause burial of chemicals, which effectively isolates them from the biotic environment.

Nonpoint source pollution contributes over 65 percent of pollutant loads to U.S. inland surface waters (Olson 1992). Thus, the above described functions of wetlands are a primary focus for control of nonpoint source pollution. On a global scale, the Pantanal wetlands of Mato Grosso do Sul, Brazil, have been cited as an example of where natural wetlands perform substantial improvement in water quality and quantity (Hammer 1992). Researchers have documented nutrient and sediment removal by riparian and wetland areas in several situations. Mitsch (1992) reports up to 96 percent retention of nutrients by constructed wetlands retained Natural wetlands similar amounts of nutrients. Other studies have indicated that presence of wetlands in the watershed results in decreased surface water concentrations of inorganic suspended solids, fecal coliform, nitrates, ammonium, total phosphorous, and lead (Johnston et al. 1990). For specific wetlands of the Northwest, Reinelt et. al (1990) have demonstrated that wetlands function to remove sediment and nitrates from water that enters and flows through the wetland.

Surface waters close to discharge from wetlands and riparian zones benefit the most. This has important biological implications. For example, small headwater streams can be significant biologically for insect production, fish spawning, and rearing, etc. Small headwater streams. are in integral contact with adjacent wetlands and dependent on the wetlands for protection from siltation, toxic chemicals, low summer stream flows, temperature extremes, flood flow attenuation, and elevated water temperatures.

The importance of wetlands in managing nonpoint source pollution is being emphasized by the Environmental Proteêtion Agency and state regulatory agencies (Robb 1992). Much of the basis for establishing the importance of wetlands in nonpoint source pollution, including results of current research, is published in Ecological Engineering (1992). The alternative management options assessed in this report have as a common basis the water quality protection by riparian and wetland area from adverse sediment and nutrient inputs and temperature increases. Forest practices that result in sediment and nutrient delivery to streams and the effects attributable thereto are reviewed elsewhere in this report.

Hydrologic Functions

Riparian and fresh water impounded wetlands have the ability to temporarily detain floodwaters and attenuate flood peaks (Wald and Schaeffer 1986). Wetlands will be most efficient at reducing downstream flooding during typical flood events and efficiency will decrease during major flood events (Wald and Schaeffer 1986). But during dryer seasons, a specific wetland's ability to detain floodwaters and reduce downstream flooding or increase base stream flow depend on the physical dimensions of the wetland and its outlet, and the characteristics of the inflow flood.

Headwater reaches of drainage systems in montane regions frequently contain meadows and bogs. These areas lack forests and have seasonally varying water tables. Soils are typically sandy peats saturated nearly to the ground surface throughdUt tFie year. These meadows can intercept considerable snowfall and can increase water yield from high- elevation drainages during snowmelt (Kittredge 1948). They also can retain runoff as ground water or temporary ponds. Such ponding is less common where soils are deep, e.g., the coastal ranges of Oregon and California or where the bedrock is volcanic or highly fractured (the Southern Cascades) (Zedler et al. 1985).

We do not have specific documentation of the importance of mid- to high-elevation meadows in regulating sediment and water transport. However, work in Europe indicates that montane meadows can reduce streamflow during storm events and elevate baseflow levels during dry seasons.

The meadows of the Pacific Coast region occupy positions in the landscape such as small valleys and swales clearly representing ground water discharge zones. Some of these meadows are also likely to act as sources of recharge to shallow aquifers. This affects downslope springs and seeps. Water enters the headwater wetlands where it is temporarily stored and is steadily released at a moderate rate to lower order channels (Zedler et al. 1985).

Similar hydrologic functions can be performed by palustrine wetlands and riparian areas of lower elevations in the forests. Much of the landscape remains intact in that physical alterations such as channelization and levee construction have not occurred. These functions can be protected by the options proposed in this report. Effectiveness of wetlands and riparian areas in lower floodplains has been limited by extensive hydrologic modification from levees, dikes, dams, channelization, etc.

Wildlife Habitat

Wildlife dependency and diversity peak at the terrestrial/aquatic boundary i.e. in riparian areas and wetlands. This coalescence of species and ecological processes is becoming better documented with each scientific study. The water source that produces this ecological epicenter does not relate closely to water quantity or size of water body. Seemingly, a different array of species are adapted to varying water body types and sizes, e.g., lakes, large rivers, perennial streams, intermittent streams, ephemeral streams, seeps, marshes, and bogs.

Wildlife have a disproportionately high use of riparian zones. Brown (1985) reports that 359 of 414 (87 percent) of wildlife species in western Oregon and Washington use riparian zones or wetlands during some season or part of their life cycle. He also states that riparian zones provide more niches than any other type of habitat. Riparian zones provide such habitat requirements as water, cover, food, plant community structure and diversity, increased humidity, high edge-to-area ratios, and migration routes (Carlson 1991). Detailed documentation of the habitat characteristics of forested riparian zones related to vegetative structure has been published by the Washington Department of
Wildlife (Carlson 1990, 1991). Table V-E-1 summarizes the recommended buffer widths along permanently flowing, fish bearing streams for various animals in Washington (Roderick and Miller 1991).

Table V-E-1. Recommended buffer widths on permanently flowing, fish bearing streams for various animals in Washington (from: Roderick and Miller, 1991).

Buffer Width	Species
600 ft. +	bald eagle - nesting, roosting, or perching cavity nesting ducks (wood duck, goldeneye, buffle head, hooded merganser) heron rookery western pond turtle sandhill crane
450 ft.	common loon nesting pileated woodpecker
300-330 ft.	beaver dabbling duck mink
200 ft.	Columbia white-tailed deer spotted frog (western Washington)
165 ft.	lesser scaup nesting harlequin duck
100 ft.	spotted frog in eastern Washington Van Dyke's salamander

Although we do not know for all species the specific habitat requirements provided by wetlands and riparian areas, the importance of undisturbed habitat can be subtle. Habitat requirements are likely to be as complex as those for reproductive and rearing success of salmonoids and other aquatic species. For example, northwest salamanders attach all egg masses to vegetation at precisely the same depth below the water surface. Therefore, any activity that changes water level before hatching could result in partial or complete reproductive failure for the pond, either through desiccation if the water level falls or through changes in temperature or other environmental conditions if water rises (Richter 1993). Chorus frogs exhibit similar subtleties in selecting ponds to avoid predators while ensuring sufficient water depth and food supply for larval maturation (Buskirk and Smith 1993). In many cases the ponds that meet amphibian reproductive requirements are small and ei:her not recorded in wetland inventories or not considered for protection in management prescriptions.

Other species' behavior apparently links closely to riparian areas including intermittent or ephemeral streams. Some species of bats may seek prey within the drainages of the smallest streams, and owls may be able to hunt more efficiently near small streams where noise levels do not interfere with their ability to locate prey.

O'Connell et al. (1993) -- for the Washington State Timber Fish and Wildlife Cooperative Monitoring, Evaluation, and Research -- surveyed current nationwide literature to develop information on riparian and wetland related wildlife species in that state. Their review, with emphasis on the Pacific Northwest, is germane to the forests of Washington, Oregon, and northern California. The rest of this section summarizes the review for several groups of wildlife.

Amphibians. Amphibians in Washington require riparian habitats for foraging, breeding and cover. The importance of the riparian zones to amphibian communities varies with the life history characteristics of each species. For example, some species breed only in mountain streams (tailed frog, Cope's salamander, Pacific giant salamander, and torrent salamander). Others such as the red-legged frog use intermittent waters possibly to reduce vulnerability of eggs and larvae to predators (Hayes and Jennings 1986 cited in O'Connell 1993). The effects of timber harvest on amphibians accrue from physical habitat damage changes in hydrology, water temperature, and substrate characteristics.

Reptiles. Association of Washington reptiles with riparian zones has not been extensively studied in the Pacific Northwest. Clearly, species such as the pond turtles are obligate wetland inhabitants, and the western terrestrial garter snake is largely aquatic. In general, six of 21 reptiles in Washington are associated with riparian or wetland habitats.

Birds. Structural components of the riparian environment seem to be most important for providing sites for feeding, breeding, nesting, roosting and perching. Specific importance of riparian zones to birds depends on climate, vegetation type, time of year, bird species characteristics, water body or stream size, structure, edge to area ratio, and occurrence of favorable microclimates. Food sources for birds in riparian areas include aquatic and wetland plants, invertebrates (insect larvae, mollusks, crustaceans), vertebrates (amphibians, fish), and flying insects.

A number of bird species depend on availability of juvenile Pacific salmon and other prey species that occur in aquatic or riparian habitats. These include common mergansers and a number of raptors such as osprey, bald eagle, and northern harrier. Some 78 species of birds in Washington breed, nest, or feed within riparian zones (O'Connell 1993). Of these species, 23 are obligate riparian inhabitants. The Washington Department of Wildlife (1992) reports 184 bird species associated with wetlands in the eastern part of the state and 127 species in the western part.

Small mammals. Vegetation, soils, and hydrologic conditions in wetland and riparian areas provide specialized microclimates for small mammals. Several mammals such as beaver, muskrat, and nutria are clearly linked to the aquatic and wetland aspects of riparian zones. O~thers such as water voles, marsh shrew, and water shrew are obligate streamside inhabitants.

Numerous other small mammal species rely on the existence of water, wet soils, or vegetation within the ripari~ zone for feeding, cover, den construction, or even for physiological reasons. For example, the mountain beaver has an inefficient kidney and therefore requires succulent vegetation and humid burrows (Feldhamer and Rochelle 1982 cited in O'Connell 1993). Other mammals such as the red-backed vole must live near water or wetlands because of poorly developed mechanisms of water conservation (Miller and Getz 1977; Merritt 1981 cited in O'Connell 1993). More than 20 species of Pacific Northwest mammals are either obligate riparian or wetland inhabitants or use such areas for specific purposes during their life cycle.

Bats. Eleven of 14 bat species occurring in the Northwest use forests as primary or secondary habitat (Dalquest 1948 cited in O'Connell 1993). Within the forest, bats seem to be opportunistic rather than restricted to specific habitat types. However, riparian areas are important for foraging and drinking. Aquatic insects are a major component of the diet of bats. In the Cascade and Oregon Coast ranges feeding rates of eight Myotis species was 10 times higher over water than in forest stands (Thomas and West 1991 cited in O'Connell 1993). Wetlands also provide critical drinking water. Even small ephemeral ponds can be used by some species (Cross 1986 cited in O'Connell 1993). Proximity to aquatic foraging or drinking sites may also be important in selection of roosting habitat although there has been little study of this to date.

Carnivores. River otters and mink are well recognized obligate riparian species. Most other carnivores spend disproportionately large amounts of time in riparian areas due to the abundance of terrestrial, wetland and aquatic prey species. Also, most carnivores will at some times of the year depend on consumption of berries and fruits. These foods are more available in the riparian zone. Availability of food during the breeding season relates directly to reproductive success. As a result, breeding success is higher among carnivores with access to riparian areas. Other important habitat features provided for carnivores are resting and denning sites arid movement corridors.

Ungulates. Five species of ungulates occupy forests within the range of the northern spotted owl, For four of the five species riparian zones play a major role in ungulate ecology in forested areas. For the endangered Columbian white-tailed deer, riparian areas are obligate habitats. Riparian habitats also provide important habitat for generalists such as the Rocky Mountain white-tailed deer, Columbian black-tailed deer, sitka black-tailed deer, mule deer, Rocky Mountain elk, and Roosevelt elk. Food, water, and cover are provided. During summer seasons, temperature moderation and availability of water attract ungulates to both wetland and riparian areas.

The O'Connell et al. (1993) review discusses the effects of timber harvest and associated forest practices for 248 terrestrial riparian invertebrate species that occur in the Northwest. Vulnerability ratings are based on an assessment of each species use of the riparian zone (e.g. water, vegetation), habitat specificity, population trend, geographic range, reproductive potential, and population concentration.

Plant Species Biodiversity in Riparian and Wetland Areas

As part of the National Wetland Inventory, the Fish and Wildlife Service in cooperation with other Federal agencies has prepared comprehensive lists of vascular plant species that occur in wetlands and their frequency of occurrence in wetland habitats. While the Pacific Northwest is not rich in wetlands as a percentage of the total landscape (slightly over 2 percent in Washington and Oregon), a relatively large percentage of total plant species in the Northwest occur in wetlands. This is not unlike the coalescence of animal species in riparian and wetland habitats. The significant percentage of plant species that occur in wetlaiids relative to the small area of wetlands on the landscape is illustrated in Table V-E-2.

Table V-E-2.

	California	Oregon	Washington
Number of vascular plant species in state[a]	6,336	3,636	2,969
Number of species in wetlands	1,933 (30 percent of total in state)	1,622 (45 percent of total in state)	1,515 (51 percent of total in state)
Number of species in riparian areas[b]	1,483 (23 percent of total in state)	1,335 (37 percent of total for state)	1,295 (44 percent of total for state)

[a]From National Wetland Inventory data base for plants that occur in wetlands, 1993.
[b]From National Wetland Inventory data base for plants that occur in wetlands. This estimate is based on a query from the entire list of vascular plant species occurring in wetlands using the key words stream, creek, river, brook, flood plain, alluvial, bottomland, banks, forest, and wood.

Many of the species that occur in wetlands are found there only a small percentage of the time over their geographic range. In most cases they are associated with upland habitats. Their occurrence in wetlands could represent genetically distinct populations or even individuals (Tiner 1991) represent sources of genetic biodiversity.

Regional Significance of Wetlands on Federal Lands

Vegetated wetlands within the range of the spotted owl represent a small portion of the landscape, perhaps as little as 1 percent (National Wetland Inventory 1990). Presence of narrow linear wetlands associated with small streams would increase this somewhat. This small segment of the landscape provides habitat requirements for a disproportionately large number of plant and animal species, some of which are unique to specific wetland types (e.g. plant and animal species associated with peat systems). Added to this are other functions provided by wetlands, e.g., water quality protection and stream flow mediation.

The significance of these wetlands is heightened by their relative rarity in a pristine state. In Washington, over a third of the state's wetlands have been lost cDahl 1990) and 90 percent of the remaining wetlands are in a degraded state (Washington Department of Wildlife' 1992). Incidence of wetland loss and degradation is much greater in flood plains at low elevations, particularly in urban areas. Thus, the forests not only provide habitat for the spotted owl but also function as reservoirs of intact wetlands. Some of these are ancient wetlands dominated by western red cedar or Sitka spruce and specialized wetlands ot several' thousand years old.

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Appendix F

Standards and Guidelines for Riparian Reserves

Background

These Standards and Guidelines were developed as a component of a strategy to protect salmon and steelhead habitat on all public lands (US Forest Service, Bureau of Land Management, National Park Service) within the range of Pacific Ocean anadromy. The Standards and Guidelines were developed by a field team of managers and specialists and a technical team of scientists, and ratified by a validation team of managers and field scientists. They have been extensively reviewed and revised by representatives at all organizational levels of both the Bureau of Land Management and the Forest Service, with full participation of the Forest Ecosystem Management Assessment Team - Aquatic/Watershed Group.

The Standards and Guidelines are a minimum set of land management prescriptions necessary to meet Aquatic Conservation Strategy Objectives.

Standards and Guidelines for Riparian Reserves

Once the Riparian Reserve width is established, either based on interim widths or watershed analysis, then land management activities allowed in the Riparian

Reserve will be determined by Standards and Guidelines for Riparian Reserves. In general, these standards and guidelines prohibit activities in Riparian Reserves that retard or prevent attainment of the Aquatic Conservation Strategy Objectives.

Timber Management

TM-1. Prohibit timber harvest, including fuelwood cutting, in Riparian Reserves, except as described below. Riparian Reserves shall not be included in calculations of the timber base.

> a. Where catastrophic events such as fire, flooding, volcanic, wind, or insect damage result in degraded riparian conditions, allow salvage and fuelwood cutting if required to attain Aquatic Conservation Strategy Objectives.
>
> b. Remove salvage trees only when watershed analysis determines that present and future woody debris needs are met and other Aquatic Conservation Strategy Oblectives are not adversely affected.
>
> c. Apply silvicultural practices for Riparian Reserves to control stocking, reestablish and culture stands, and acquire desired vegetation characteristics needed to attain Aquatic Conservation Strategy Objectives.

Roads Management

RF-1. Cooperate with federal, state, tribal, and county agencies to achieve consistency in road design, operation, and maintenance necessary to attain Aquatic Conservation Strategy Objectives.

RF-2. For each existing or planned road, meet Aquatic Conservation Strategy Objectives by:

a. Minimizing road and landing locations in Riparian Reserves.

b. Completing watershed analyses (including appropriate geotechnical analyses) prior to construction of new roads or landings in Riparian Reserves.

c. Preparing road design criteria, elements, and standards that govern construction and reconstruction.

d. Preparing operation and maintenance criteria that govern road operation, maintenance, and management.

e. Minimizing disruption of natural hydrologic flow paths, including diversion of streamflow and interception of surface and subsurface flow.

f. Restricting sidecasting as necessary to prevent the introduction of sediment to streams.

RF-3. Determine the influence of each road on the Aquatic Conservation Strategy Objectives through watershed analysis. Meet Aquatic Conservation Strategy Objectives by:

a. Reconstructing roads and associated drainage features that pose a substantial risk.

b. Prioritizing reconstruction based on current and potential impact to riparian resources and the ecological value of the riparian resources affected.

c. Closing and stabilizing, or obliterating and stabilizing roads based on the ongoing and potential effects to Aquatic Conservation Strategy Objectives and considering short-term and long-term transportation needs.

RF-4. New culVèrts, bridges and other stream crossings shall be constructed, and existing culverts, bridges and other stream crossings determined to pose a substantial risk to riparian conditions will be improved, to accommodate at least the 1CC-year flood, including associated bedload and debris. Priority for upgrading will be based on the potential impact and the ecological value of the riparian resources affected. Crossings will be constructed and maintained to prevent diversion of streamflow out of the channel and down the road in the event of crossing failure

RF-5. Minimize sediment delivery to streams from roads. Outsloping of the roadway surface is preferred, except in cases where outsloping would increase sediment delivery to streams or where outsloping is infeasible or unsafe. Route road drainage away from potentially unstable channels, fills, and hillslopes.

RF-6. Provide and maintain fish passage at all road crossings of existing and potential fish-bearing streams.

RF-7. Develop and implement a Road Management Plan or a Transportation Management Plan that will meet the Aquatic Conservation Strategy Objectives. As a minimum, this plan shall include provisions for the following activities:

a. Post-storm inspections and maintenance.

b. During-storm inspections and maintenance.

c. Road operation and maintenance giving high priority to identifying and correcting road drainage problems that contribute to degrading riparian resources.

d. Regulation of traffic during wet periods to prevent damage to riparian resources.

e. Establish the purpose of each

road by developing the Road Management Objective.

Grazing Management

GM-1. Adjust grazing practices to eliminate impacts that retard or prevent attainment of Aquatic Conservation Strategy Objectives. If adjusting practices is not effective, eliminate grazing.

GM-2. Locate new livestock handling and/or management facilities outside Riparian Reserves. For existing livestock handling facilities inside the Riparian Reserve, ensure that Aquatic Conservation Strategy Objectives are met. Where these objectives cannot be met, require relocation or removal of such facilities.

GM-3. Limit livestock trailing, bedding, watering, loading, and other handling efforts to those areas and times that will ensure Aquatic Conservation Strategy Objectives are met.

Recreation Management

RM-1. Design, construct, and operate recreation facilities, including trails and dispersed sites, within Riparian Reserves in a manner that contributes to attainment of Aquatic Conservation Strategy Objectives. For existing recreation facilities inside Riparian Reserves, ensure that Aquatic Conservation Strategy Objectives are met. Where Aquatic Conservation Strategy Objectives cannot be met, require relocation or closure of recreation facilities.

RM-2. Adjust dispersed and developed recreation practices that retard or prevent attainment of Aquatic Conservation Strategy Objectives. Where adjustment measures such as education, use limitations, traffic control devices, increased maintenance, relocation of facilities, and/or specific site closures are not effective, eliminate the practice or occupancy.

RM-3. Wild and Scenic Rivers and Wilderness Management plans will address attainment of Aquatic Conservation Strategy Objectives.

Minerals Management

MM-1. Require a reclamation plan, approved Plan of Operations, and reclamation bond for all minerals operations that include Riparian Reserves. Such plans and bonds must address the costs of removing facilities, equipment, and materials; recontouring of disturbed areas to near pre-mining topography; isolation and neutralization or removal of toxic or potentially toxic materials; .salvage and replacement of topsoil; and seedbed preparation and revegeation to meet Aquatic Conservation Strategy Objectives.

MM-2. Locate structures, support facilities, and roads outside Riparian Reserves. Where no alternative to siting facilities in Riparian Reserves exists, locate in a way compatible with Aquatic Conservation Strategy Objectives. Road construction will be kept to the minimum necessary for the approved mineral activity. Such roads will be constructed and maintained to meet Roads Management Standards and to minimize damage to resources in the Riparian Reserve. When a road is no longer required for mineral or land management activities, it will be closed, obliterated, and stabilized.

MM-3. Prohibit solid and sanitary waste facilities in Riparian Reserves. If no alternative to locating mine waste (waste rock, spent ore, tailings) facilities in Riparian Reserves exists, and releases can be prevented, and stability can be ensured, then:

a. Analyze the waste material using the best conventional sampling methods and analytic techniques to determine it's chemical and physical stability characteristics.

b. Locate and design the waste facilities using best conventional techniques to ensure mass stability and prevent the release of acid or toxic materials. If the best conventional technology is not sufficient to prevent such releases and ensure stability over the long term, prohibit such facilities in Riparian Reserves.

c. Monitor waste and waste facilities after operations to ensure chemical and physica~l stability and to meet Aquatic Conservation Strategy Objectives.

d. Reclaim waste facilities after

operations to ensure chemical and physical stability and to meet Aquatic Conservation Strategy Objectives.

e. Require reclamation bonds adequate to ensure long-term chemical and physical stability of mine waste facilities.

MM-4. For leasable minerals, prohibit surface occupancy within Riparian Reserves for oil, gas, and geothermal exploration and development activities where contracts and leases do not already exist. Adjust the operating plans of existing contracts to eliminate impacts that retard or prevent the attainment of Aquatic Conservation Strategy Objectives.

MM-5. Sand and gravel mining and extraction within Riparian Reserves will occur only if Aquatic Conservation Strategy Objectives can be met.

MM-6. Develop inspection and monitoring requirements and include such requirements in mineral plans, leases or permits. Evaluate the results of inspection and monitoring to modify mineral plans, leases and permits as needed to eliminate impacts that retard or prevent attainment of Aquatic Conservation Strategy Objectives.

Fire/Fuels Management

FM-1. Design fuel treatment and fire

suppression strategies, practices, and activities to meet Aquatic Conservation Strategy Objectives, and to minimize disturbance of riparian ground cover and vegetation. Strategies should recognize the role of fire in ecosystem function and identify those instances where fire suppression or fuel management activities could be damaging to long-term ecosystem function.

FM-2. Locate incident bases, camps, helibases, staging areas, helispots and other centers for incident activities outside of Riparian Reserves. If the only suitable location for such activities is within the Riparian Reserve, an exemption may be granted following a review and recommendation by a resource advisor. The advisor will prescribe the location, use conditions, and rehabilitation requirements. Utilize an interdisciplinary team to predetermine suitable incident base and helibase locations.

FM-3. Minimize delivery of chemical retardant, foam, or additives to surface waters. An exception may be warranted in situations where over-riding immediate safety imperatives exist, or, following a review and recommendation by a resource advisor, when an escape would cause more long-term damage.

FM-4. Design prescribed burn projects and prescriptions to contribute to attainment of Aquatic Conservation Strategy Objectives.

FM-5. Immediately establish an emergency team to develop a rehabilitation treatment plan needed to attain Aquatic Conservation Strategy Objectives whenever Riparian Reserves are significantly damaged by a wildfire or a prescribed fire burning out of prescription.

Lands

LH-1. For hydroelectric and other surface water development proposals, require in-stream flows and habitat conditions that maintain or restore riparian resources, favorable channel conditions, and fish passage. Coordinate this process with the appropriate state agencies. During relicensing of hydroelectric projects, provide written and timely license conditions to Federal Energy Regulatory Commission (FERC) that require flows and habitat conditions that maintain/restore riparian resources and channel integrity. Coordinate relicensing projects with the appropriate state agencies.

LH-2. Locate new facilities outside of Riparian Reserves. For existing support facilities inside the Riparian Reserves that are essential to proper management, provide recommendations to FERC that ensure that Aquatic Conservation Strategy Objectives are met. Where these objectives cannot be met, provide recommendations to FERC that such support facilities should be relocated. Hydroelectric facilities that must be located in the Riparian Reserves will be located, operated, and maintained to eliminate adverse effects that retard or prevent attainment of Aquatic Conservation Strategy Objectives.

LH-3. Issue leases, permits, rights-of-way, and easements to avoid adverse effects that retard or prevent attainment of Aquatic Conservation Strategy Objectives. Adjust existing leases, permits, rights-of-way, and easements to eliminate adverse effects that retard or prevent the attainment of Aquatic Conservation Strategy Objectives. If adjustments are not effective, eliminate the activity. priority for modifying existing leases, permits, rights-of-way and easements will be based on the actual or potential impact and the ecological value of the riparian resources affected.

LH-4. Use land acquisition, exchange, and conservation easements to meet Aquatic Conservation Strategy Objectives and facilitate restoration of fish stocks and other species at risk of extinction.

General Riparian Area Management

RA-1. Identify and attempt to secure mn-stream flows needed to maintain riparian resources, channel conditions, and aquatic habitat.

RA-2 Fell trees in Riparian Reserves when they pose a safety risk. Keep felled trees on-site when needed to meet woody debris objectives.

RA-3. Herbicides, insecticides, and other toxicants, and other chemicals shall be applied only in a manner that avoids impacts that retard or prevent attainment of Aquatic Conservation Strategy Objectives.

RA-4. Locate water drafting sites to minimize adverse effects on stream channel stability, sedimentation, and in-stream flows needed to maintain riparian resources, channel conditions, and fish habitat.

Watershed and Habitat Restoration

WR-1. Design and implement watershed restoration projects in a manner that promotes long-term ecological integrity of ecosystems, conserves the genetic integrity of native species, and attains Aquatic Conservation Strategy Objectives.

WR-2. Cooperate with federal, state, local, and tribal agencies, and private landowners to develop watershed-based Coordinated Resource Management Plans or other cooperative agreements to meet Aquatic Conservation Strategy Objectives.

WR-3. Do not use mitigatiSn or planned restoration as a substitute for preventing habitat degradation.

Fish and Wildlife Management

FW-1. Design and implement fish and wildlife habitat restoration and enhancement activities in a manner that contributes to attainment of Aquatic Conservation Strategy Objectives.

FW-2. Design, construct and operate fish and wildlife interpretive and other userenhancement facilities in a manner that does not retard or prevent attainment of Aquatic Conservation Strategy Objectives. For existing fish and wildlife interpretative and other user-enhancement facilities inside Riparian Reserves, ensure that Aquatic Conservation Strategy Objectives are met. Where Aquatic Conservation Strategy Objectives cannot be met, relocate or close such facilities.

FW-3. Cooperate with federal, tribal, and state wildlife management agencies to identify and eliminate wild ungulate impacts that are inconsistent with attainment of Aquatic Conservation Strategy Objectives.

FW-4. Cooperate with federal, tribal, and state fish management agencies to identify and eliminate impacts associated with habitat manipulation, fish stocking, harvest and poaching that threaten the continued existence and distribution of native fish stocks inhabiting federal lands.

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Appendix G

Procedure Used for Determination of Stream Densities

The interim guidelines contained in Appendix 5K of the Scientific Analysis Team (Thomas et al. 1993) report require a variable width Riparian Habitat'Coservation Area (now referred to as a Riparian Reserve or RR) for three categories of streams: perennial- fish bearing, perennial-nonfish-bearing, and intermittent. The Scientific Analysis Team (Thomas et al. 1993) prescriptions are intended to include ephemeral channels. To estimate the effects of RRs on Allowable Sale Quantity, we developed a method to estimate the number of miles in each stream category. National Forests in Region 6 (Region 6 National Forests) have data on stream class that allows calculation of the miles of perennial streams which are fish bearing (Class I and II) and which are non-fish bearing (Class III). Region 6 National Forests have estimates of intermittent streams (Class IV) but few Districts have data on each of the perennial categories directly. The major data void was estimates of the intermittent stream miles within each National Forest or Bureau of Land Management District. We estimated the total drainage density for each of the National Forests and Bureau of Land Management Districts using the following procedure.

A total of 56 7.5-minute 1:24,030 U.S. Geological Society topographic quadrangles were sampled to represent different geomorphic areas within the northern spotted owl range of Washington, Oregon, and northern California (Table V-C-i). Figure V-C-i shows the relative location for each of the sample quads. Existing data on miles of stream length by stream order for Grouse Creek, an area on the Six Rivers National Forest, was also used.

A 25 square kilometer sample area for each National Forest quad was located as follows. Generally, the first intersection of Universal Transverse Mercator tics in the southwest corner of each quad was selected as the starting point. From this point we moved two tics to the east and three to the north to locate an intersection of Universal Transverse Mercator lines that became the southwest corner of the 25-square kilometer square sample area. The l~est of the sample area 5 kilometers on a side was then delineated. In one case, the 25-square -kilometer sample area was moved southward on the quad to place it within the National Forest land for which it was selected.

Bureau of Land Management sample areas were chosen to represent townships that were entirely under Bureau of Land Management administration and as near to the center of the quad as possible. Occasionally the sample areas were not rectangular due to township delineation. When the sample areas were irregular in shape, the area was "trimmed to fit a rectangular area within the irregular polygon boundary.

All stream channels within each 25-square kilometer sample area were delineated manually using crenulations of contour lines in the following manner. First-order channels were marked by extending a red line past the last contour line showing a crenulation and halfway to the next contour line. The network of streams marked on the 25-square kilometer sample were color coded for stream order (Strahler, 1957): thirdorder and higher order streams were colored blue, second-order streams were colored green, and first-order streams remained red. Initially, the Region 6 Geometronics Group digitized the sample quads and attributed by stream order based on the color code. After about 15 of the quads had been manually digitized, the Geometronics group began tracing the stream network onto acetate that allowed them to scan the streams manuscripts into a Geographic Information System using LTPLUS software. Stream order was assigned to each segment based on the original color coded map.

Table V-G-1. Selected 7.5 Minute USGS Quads

Forest / BLM District		USGS Quad
Olympic		Mt. Tebo
		Deadman's Hill
Mt. Baker-Snoqualmie		Bedal
		Greenwater
		Pugh Mountain
Gifford Pinchot		Trout Lake
		Smith Creek Butte
		Quartz Creek Butte
		Purcell Mountain
		Blue Lake
Wenatchee		Pyramid Mountain
		Frost Mountain
		Meeks
		Peshastin
		Liberty
Okanogan		Hoodoo Peak
		Tiffany Mountain
Mt. Hood		Three Lynx
		Wolf Peak
		Wanderer's Peak
	*	Soosap Peak
Willamette		Coffin Mountain
		Grasshopper Mountain

Forest / BLM District		USGS Quad
BLM - Salem		Jordan
BLM - Salem		Meacham Corner
BLM - Eugene		Walton
BLM - Medford		Daniel's Creek
BLM - Medford		Murphy
BLM - Roseburg		Harrington Creek
BLM - Roseburg		McCullough Creek
Klamath		Happy Camp
		Garner Mountain
Shasta-Trinity		Pony Buck Peak East
		Del Loma
Six Rivers	**	Grouse Creek
		Tish Tang Point
		Lonesome Ridge
Mendicino		Hull Mountain
		Leech Lake Mountain

Mt. Hood		Three Lynx
		Wolf Peak
		Wanderer's Peak
	*	Soosap Peak
Willamette		Coffin Mountain
		Grasshopper Mountain
		Sinker Mountain
	*	Gawley Creek
Umpqua		Abbot Butte
		Reynold's Ridge
		Buckeye Lake
		Garwood Butte
Rogue River		Red Blanket Mountain
		Brown Mountain
Siuslaw	*	Trask Mountain
	*	Kilchis River
	*	Glenbrook
		Baldy Mountain
Siskiyou		Onion Mountain
		Mt. Peavine
		Quail Prairie Mountain
Deschutes		Black Butte
Winema		Sun Pass
		Lake of the Woods - North

* Represents USFS and BLM lands

** Data provided by the Six Rivers NF

Basic data derived from the 25-square kilometer samples was expressed in kilometers of stream in first-, second-, and third-and-higher-order streams per square kilometer. The data are given in Table V-G-2. Data were organized by geoclimati>c prQvince in an attempt to discern patterns in stream density by stream order. Af(er d7scussing about the data and the variability within geoclimatic areas, we decided to use an average of the quads for each Forest rather than the values from the larger geoclimatic areas. The values for stream density on the Klamath National Forest was adjusted based on professional knowledge of the Forests. The Klamath National Forest is divided into a relative flat and dry east side and a steep, wet west side. The Garner Mountain U.S. Geological Society quad on the east side had a very low stream density compared to the Happy Camp quad on the west side. When data from these two quads were averaged together, the overall stream density for the Klamath National Forest was relatively low which is not representative of the Forest overall. The west side stream density was recalculated by averaging the stream densities for the Shasta Trinity and Six Rivers National Forests. These Forests are similar in topography and climate to the west side of the Klamath National Forest.

We multiplied the average sampled stream density of each National Forest within the range of the northern spotted owl by net area of each Forest. Stream densities were estimated for the Siuslaw and Siskiyou National Forests based on other coastal quads, Bureau of Land Management quads, and available research case studies.

The Willamette, the Umpqua, and the Gifford Pinchot National Forests have coded Class IV streams in their Geographic Information System (GIS) layers. We requested that the Forest Hydrologist and Forest GIS group produce 1:24,000 overlays of the stream classification for each of the sample quads. Overlays were used to make comparisons on the UMP and GIP; hardcopy maps were used for the WIL comparisons.

The conclusions we reached through the comparison were:

1. There was ho consistent relationship between stream order and stream class.

2. Third-order and greater streams were uniformly accepted as perennial.

3. First-order streams were uniformly accepted as intermittent.

The group agreed that the greatest degree of confidence about stream class was associated with the perennial streams (Class 1,11, III). We also agreed that it would be appropriate to estimate the miles of Class IV (intermittent/ephemeral streams) by subtracting the miles of Class I, II, III from an estimate of total stream miles based on the stream densities developed from the quad "window samples.

Table V-G-2. Stream Miles by Stream Order

			Area		Miles by Stream Order				Miles/		Area	Km by Stream Order				km /	
	USGS Quad Name		(sq. km)	(sq. mi.)	1	2	3+	Total	sq. mi.	avg.	(sq. km)	1	2	3+	Total	sq km	avg.
1	Mt. Tebo	OLY	24.96	9.64	38.23	10.23	12.73	61.19	6.35		24.96	61.17	16.37	20.37	97.90	3.92	
2	Deadman's Hill	OLY	24.99	9.65	63.36	16.38	15.04	94.78	9.82	8.09	24.99	101.38	26.21	24.06	151.65	6.07	5.00
3	Bedal	MBS	25.62	9.89	28.85	9.58	8.20	46.63	4.71		25.62	46.16	15.33	13.12	74.61	2.91	
4	Greenwater	MBS	24.97	9.64	57.69	15.80	12.63	86.12	8.93		24.97	92.30	25.28	20.21	137.79	5.52	
5	Pugh Mountain	MBS	25.03	9.66	39.67	9.01	16.51	65.19	6.75	6.80	25.03	63.47	14.42	26.42	104.30	4.17	4.20
6	Trout Lake	GIP	25.31	9.77	29.22	13.35	10.36	52.93	5.42		26.31	46.75	21.36	16.58	84.69	3.35	
7	Smith Creek Butte	GIP	25.02	9.66	73.38	18.20	20.22	111.80	11.57		25.02	117.41	29.12	32.35	178.88	7.15	
8	Quartz Creek Butte	GIP	25.01	9.66	40.66	10.01	10.54	61.21	6.34		25.01	65.06	16.02	16.86	97.94	3.92	
9	Purcell Mountain	GIP	24.99	9.65	43.75	13.35	9.64	66.74	6.92		24.99	70.00	21.36	15.42	106.78	4.27	
10	Blue Lake	GIP	25.20	9.73	32.56	11.86	10.96	55.38	5.69	7.19	25.20	52.10	18.98	17.54	88.61	3.52	4.44
11	Pyramid Mountain	WEN	24.97	9.64	85.35	20.24	14.18	119.76	12.42		24.97	136.56	32.38	22.66	191.60	7.67	
12a	Frost Mountain	WEN	25.00	9.65	28.10	10.18	6.69	44.97	4.66		25.00	44.96	16.29	10.70	71.95	2.88	
12b	Meeks	WEN	25.14	9.71	48.91	12.07	14.66	75.64	7.79		25.14	78.26	19.31	23.48	121.02	4.81	
12c	Peshastin	WEN	25.00	9.65	59.70	10.71	11.17	81.58	8.45		25.00	95.52	17.14	17.87	130.53	6.22	
12d	Liberty	WEN	24.96	9.64	58.07	17.12	17.10	92.29	9.58	8.58	24.96	92.91	27.39	27.36	147.66	5.92	5.30

5	Pugh Mountain	MBS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	Trout Lake	GIP	25.31	9.77	29.22	13.35	10.36	52.93	5.42		25.31	48.75	21.38	16.58	84.69	3.35	
7	Smith Creek Butte	GIP	25.02	9.66	73.38	18.20	20.22	111.80	11.57		25.02	117.41	29.12	32.35	178.88	7.15	
8	Quartz Creek Butte	GIP	25.01	9.66	40.66	10.01	10.54	61.21	6.34		25.01	65.06	16.02	16.86	97.94	3.92	
9	Purcell Mountain	GIP	24.99	9.86	43.75	13.35	9.64	66.74	6.92		24.99	70.00	21.38	15.42	106.78	4.27	
10	Blue Lake	GIP	25.20	9.73	32.56	11.86	10.96	55.38	5.69	7.19	25.20	52.10	18.98	17.54	88.61	3.52	4.44
11	Pyramid Mountain	WEN	24.97	9.64	85.35	20.24	14.16	119.76	12.42		24.97	136.56	32.38	22.66	191.60	7.67	
12a	Frost Mountain	WEN	25.00	9.65	28.10	10.18	6.69	44.97	4.66		25.00	44.96	16.29	10.70	71.95	2.88	
12b	Meeks	WEN	25.14	9.71	48.91	12.07	14.66	76.64	7.79		25.14	78.26	19.31	23.48	121.02	4.81	
12c	Peshastin	WEN	25.00	9.65	58.70	10.71	11.17	81.58	8.45		25.00	95.52	17.14	17.87	130.53	6.22	
12d	Liberty	WEN	24.96	9.64	58.07	17.12	17.10	92.29	9.58	8.58	24.96	92.91	27.39	27.36	147.66	5.92	5.30
13	Hoodoo Peak	OKA	25.20	9.73	33.30	11.33	10.64	56.27	5.68		25.20	53.28	18.13	17.02	88.43	3.51	
14	Tiffany Mountain	OKA	24.92	9.62	22.62	6.03	6.53	35.18	3.66	4.67	24.92	36.19	9.65	10.45	56.29	2.26	2.88
15	Three Lynx	MTH	25.02	9.66	41.56	12.10	7.13	60.79	6.29		25.02	66.50	19.36	11.41	97.26	3.89	
16	Wolf Peak	MTH	25.02	9.66	17.61	6.26	1.82	25.69	2.66		25.02	28.18	10.02	2.91	41.10	1.64	
17	Wanderers Peak	MTH	24.97	9.64	48.60	14.76	12.25	75.61	7.84		24.97	77.76	23.62	19.60	120.98	4.84	
18	Soosap Peak	MTH/BLM	24.98	9.64	39.32	11.04	11.55	61.91	6.42	5.80	24.98	62.91	17.66	18.48	99.06	3.97	3.59
19	Coffin Mountain	WIL	24.99	9.65	34.53	18.22	1.54	54.29	5.63		24.99	67.40	33.60	2.46	103.46	4.14	
20	Grasshopper Mountain	WIL	24.96	9.64	28.21	7.18	4.66	40.05	4.16 *		24.96	45.14	11.49	7.46	64.08	2.57	
21	Sinker Mountain	WIL	24.98	9.64	48.46	14.98	11.27	74.71	7.76		24.98	77.54	23.97	18.03	119.64	4.79	
22	Gawley Creek	WIL/BLM	24.97	9.64	31.62	7.07	5.49	44.18	4.58	5.53	24.97	50.59	11.31	8.78	70.69	2.83	3.58
23	Abbot Butte	UMP	24.93	9.63	42.16	14.63	9.32	66.11	6.87		24.93	67.46	23.41	14.91	105.78	4.24	
24	Reynolds Ridge	UMP	24.90	9.61	54.95	11.59	12.92	79.46	8.27		24.90	87.92	18.54	20.67	127.14	5.11	
25	Buckeye Lake	UMP	25.00	9.65	37.04	15.02	11.18	63.24	6.55		25.00	59.26	24.03	17.89	101.18	4.05	
26	Garwood Butte	UMP	25.06	9.68	12.80	5.03	5.44	23.27	2.41	6.02	25.06	20.48	8.05	8.70	37.23	1.49	3.72
27	Red Blanket Mountain	ROR	25.06	9.68	28.89	9.46	6.34	44.69	4.62		25.06	46.22	15.14	10.14	71.50	2.85	
28	Brown Mountain	ROR	25.00	9.65	20.56	7.65	6.00	34.21	3.54	4.08	25.00	32.90	12.24	9.60	54.74	2.19	2.52
29	Trask Mountain	BLM/SIU	25.03	9.66	36.54	14.60	11.54	62.68	6.49		25.03	58.46	23.36	18.46	100.29	4.01	
30	Kilchis River	BLM/SIU	21.60	8.34	43.89	13.81	13.46	71.16	8.53		21.60	70.22	22.10	21.54	113.86	5.27	
31	Glenbrook	BLM/SIU	23.33	9.01	37.28	11.72	4.80	53.80	5.97		23.33	59.65	18.75	7.68	86.06	3.69	
32	Baldy Mountain	SIU	24.98	9.64	40.19	15.66	11.06	66.91	6.94	6.98	24.98	64.30	25.06	17.70	107.06	4.29	4.31
33	Onion Mountain	SIS	24.95	9.63	65.09	17.15	11.82	94.06	9.76		24.95	104.14	27.44	18.91	150.50	6.03	
34	Mt. Peavine	SIS	25.27	9.76	64.59	16.22	13.57	94.38	9.67		25.27	103.34	25.95	21.71	151.01	5.98	
35	Quail Prairie Mountain	SIS	25.02	9.66	38.05	13.29	9.36	60.70	6.26	8.57	25.02	60.88	21.26	14.98	97.12	3.88	5.30
36	Black Butte	DES	24.98	9.64	13.73	3.50	0.61	17.84	1.85		24.98	21.97	5.60	0.98	28.54	1.14	
37	Sun Pass	WIN	25.02	9.66	20.22	9.47	4.47	34.16	3.54		25.02	32.35	15.15	7.16	54.66	2.18	
38	Lake of the Woods-North	WIN	25.04	9.67	13.06	6.49	4.26	23.81	2.46	3.00	25.04	20.90	10.38	6.82	38.10	1.52	1.85
39	Jordan	BLM-SALEM	23.38	9.03	56.33	18.93	11.25	86.51	9.58		23.38	90.13	30.29	18.00	138.42	5.92	
40	Meacham Corner	BLM-SALEM	23.11	8.92	29.70	8.68	8.97	47.35	5.31		23.11	47.52	13.89	14.36	75.76	3.28	
41	Walton	BLM-EUG	22.92	8.86	27.76	10.95	9.80	48.51	5.48		22.92	44.42	17.52	15.68	77.62	3.39	
42	Daniel's Creek	BLM-MED	22.82	8.81	76.14	20.01	16.61	112.76	12.80		22.82	121.82	32.02	26.58	180.42	7.91	
43	Murphy	BLM-MED	24.29	9.38	32.47	9.82	5.56	47.85	5.10		24.29	51.95	15.71	8.90	76.56	3.15	
44	Harrington Creek	BLM-ROS	22.56	8.72	53.91	15.06	11.34	80.31	9.21		22.58	86.26	24.10	18.14	128.50	5.69	
45	McCullough Creek	BLM-ROS	23.41	9.04	55.18	13.90	15.50	84.58	9.36	8.12	23.41	88.29	22.24	24.80	135.33	5.78	5.02
46	Happy Camp	KLA	25.15	9.71	38.66	13.46	12.84	64.96	6.69		25.15	61.86	21.54	20.54	103.94	4.13	
47	Garner Mountain	KLA	25.51	9.85	14.03	6.06	3.76	23.85	2.42	4.56	25.61	22.45	9.70	6.02	38.16	1.50	2.81
48	Pony Buck Peak East	SH-T	24.78	9.57	41.54	12.28	6.95	60.77	6.35		24.78	66.46	19.65	11.12	97.23	3.92	
49	Del Loma	SH-T	24.94	9.63	30.81	5.66	9.48	45.95	4.77	5.56	24.94	49.30	9.06	15.17	73.52	2.95	3.44
	Grouse Creek	SIX	146.55	56.58	NA	NA	NA	NA	8.11		24.70	NA	NA	NA	NA	6.04	
50	Tish Tang Point	SIX	24.70	9.54	30.51	9.41	8.98	48.90	5.13		24.70	48.82	15.06	14.37	78.24	3.17	
51	Lonesome Ridge	SIX	25.22	9.74	29.44	12.04	3.57	45.05	4.63	5.95	25.22	47.10	19.26	5.71	72.08	2.86	3.69
52	Hull Mountain	MEND	25.14	9.71	60.87	18.69	8.17	87.73	9.04		25.14	97.39	29.90	13.07	140.37	5.58	
53	Leech Lake Mountain	MEND	25.06	9.68	59.90	16.83	9.93	86.66	8.96	9.00	25.06	95.84	26.93	15.89	138.66	5.53	5.56

* Adjusted by Harr
(Augusta Creek area)

48	Pony Buck Peak East	SH-T	24.78	9.57	41.54	12.28	6.95	60.77	6.35		24.78	66.46	19.65	11.12	97.23	3.92	
49	Del Loma	SH-T	24.94	9.63	30.81	5.68	9.48	45.85	4.77	5.56	24.94	49.30	9.06	15.17	73.52	2.95	3.44
	Grouse Creek	SIX	146.55	56.58	NA	NA	NA	NA	6.11		24.70	NA	NA	NA	NA	6.04	
50	Tish Tang Point	SIX	24.70	9.54	30.51	9.41	8.98	48.90	5.13		24.70	48.82	15.06	14.37	78.24	3.17	
51	Lonesome Ridge	SIX	25.22	9.74	29.44	12.04	3.57	45.05	4.63	5.95	25.22	47.10	19.26	5.71	72.08	2.86	3.69
52	Hull Mountain	MEND	25.14	9.71	60.87	18.68	8.17	87.73	9.04		25.14	97.39	29.90	13.07	140.37	5.58	
53	Leech Lake Mountain	MEND	25.06	9.68	59.90	16.83	9.93	86.66	8.96	9.00	25.06	95.84	26.93	15.89	138.66	5.53	5.56

* Adjusted by Harr
(Augusta Creek area)

Forests updated their 1984 estimates of miles of stream within each stream class. The mileage of fish-bearing streams (Classes I and II) and perennial non-fish-bearing streams (Class III) was subtracted from total stream length to obtain total length of intermittent/ephemeral (Class IV) stream channels in kilometers.

The Bureau of Land Management protocol for designating streams was followed on Bureau of Land Management lands. Third-order streams and above were designated fish- bearing streams, second-order streams were designated perennial non-fish-bearing, and first-order channels were designated intermittent streams. Table V-G-3 contains the lengths of Bureau of Land Management streams by stream order.

Table V-G-3. Miles of Stream by Stream Order for Bureau of Land Management Districts.

Table V-G-3. Miles of Stream by Stream Order for Bureau of Land Management Districts.

District	RMP acres	1	2	3	4	5	6
Salem	393600	+	868	399	192	79	59
Eugene	316592	+	1503	282	130	36	28
Roseburg	419400	+	1592	424	309	88	57
Coos Bay	329583	+	2204	325	156	65	52
Medford	866300	+	6387	1004	400	167	130
Klamath Falls	212000	+	6.3	22	16	1	7

\+ Not considered perennial

Table V-G-4 contains the final tabulation of miles of stream by category and the estimated miles of intermittent and ephemeral streams.

The stream network samples are contained as a set of graphic images (Fig. V-G-2) at the end of this appendix. The samples are organized by major rock stability groups as defined below.

Resistant

Form steep slopes with thin soils, subject to narrow, shallow, rapid landslides (debris flows) from highly unstable areas at the heads of stream channels; stream channel and banks may be scoured for long distances.

<u>Resistant sediments</u>: Weather relatively rapidly to soil thicknesses that are unstable on steep slopes.

<u>Resistant Other</u>: Weather more slowly and require a longer time to accumulate soils to unstable thicknesses.

Granitics: Where relatively unweathered, steep slopes form and are subject to debris flows. Where granitics are weathered, they are subject to severe surface erosion.

Weak

Form gentle slopes with thick soils that are subject to large, deep, slow landslides (earthflows); may constrict or deflect stream channels.

Intermediate

Form moderate slopes with variable soil depths; where soils accumulate on lower slopes, streambank landslides are common in inner gorges.

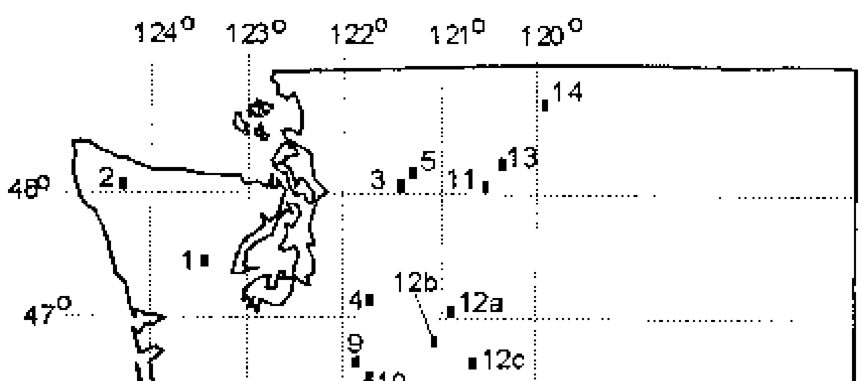
Intermediate Sediments: Resistant and weak rock types mixed from faulting or sedimentary layers, variable landslide processes.

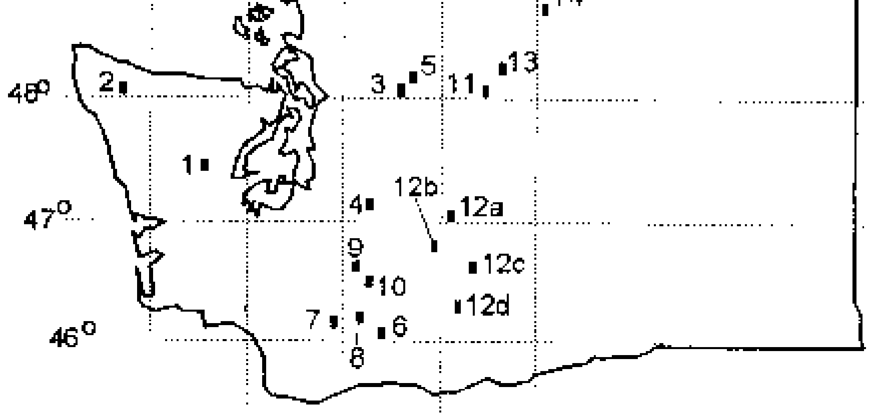
Serpentinite/Peridotite: Variable internal strength due to local faulting results in variable landslide processes.

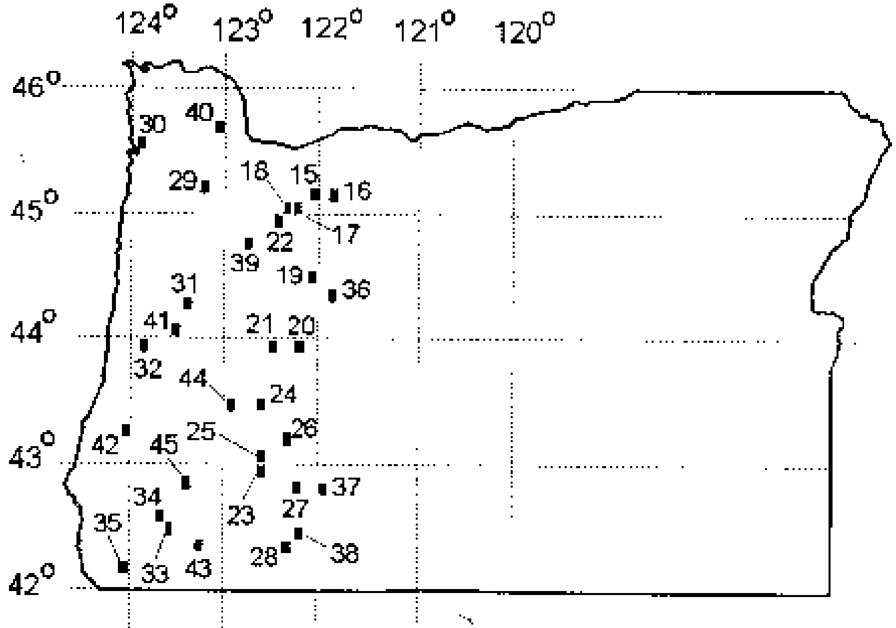
Unconsolidated

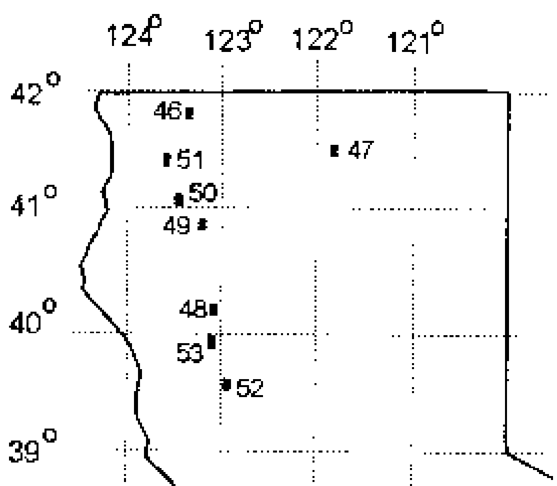
Loose alluvial, colluvial, glacial, marine terrace, and ash d~posits generally located on gentle slopes that are subject to accelerated channel erosion and streambank landslides.

1. Mt Tebo
2. Deadman's Hill
3. Bedal
4. Greenwater
5. Pugh Mountain
6. Trout Lake
7. Smith Creek Butte
8. Quartz Creek Butte
9. Purcell Mountain
10. Blue Lake
11. Pyramid Mountain
12a. Frost Mountain
12b. Meeks
12c. Peshastin
12d. Liberty
13. Hoodoo Peak
14. Tiffany Mountain





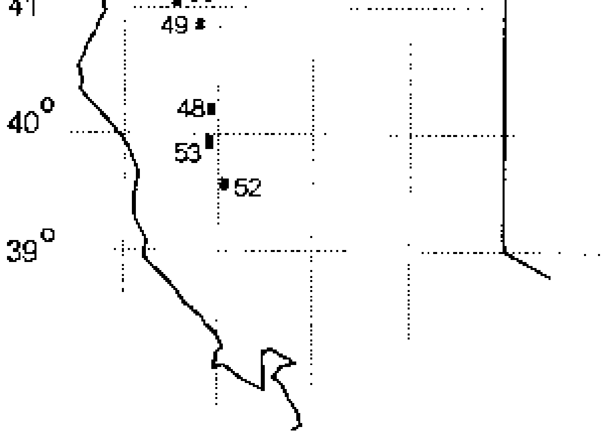




10. Blue Lake
11. Pyramid Mountain
12a. Frost Mountain
12b. Meeks
12c. Peshastin
12d. Liberty
13. Hoodoo Peak
14. Tiffany Mountain

15. Three Lynx
16. Wolf Peak
17. Wanderer's Peak
18. Soosap Peak
19. Coffin Mountain
20. Grasshopper Mountain
21. Sinker Mountain
22. Gawley Creek
23. Abott Butte
24. Reynold's Ridge
25. Buckeye Lake
26. Garwood Butte
27. Red Blanket Mountain
28. Brown Mountain
29. Trask Mountain
30. Kilchis River
31. Glenbrook
32. Baldy Mountain
33. Onion Mountain
34. Mt. Peavine
35. Quail Prairie Mountain
36. Black Butte
37. Sun Pass
38. Lake of the Woods - North
39. Jordan
40. Meacham Corner
41. Walton
42. Daniel's Creek
43. Murphy
44. Harrington Creek
45. McCullough Creek

46. Happy Camp
47. Garner Mountain



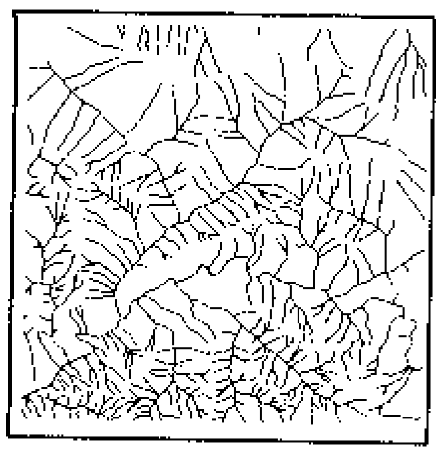
41. Walton
42. Daniel's Creek
43. Murphy
44. Harrington Creek
45. McCullough Creek

46. Happy Camp
47. Garner Mountain
48. Pony Buck Peak East
49. Del Loma
50. Tish Tang Point
51. Lonesome Ridge
52. Hull Mountain
53. Leech Lake Mountain

Figure V-G-1. Map of sample U.S. Geological Society quad maps used for determining streams densities.

Olympics

Intermediate Sediments



Deadman's Hill
Olympic NF
9.82 mi. / sq. mile
1000 feet (msl)

Resistant, other

Mt. Tebo
Olympic NF
6.35 mi. / sq. mile
1800 feet (msl)

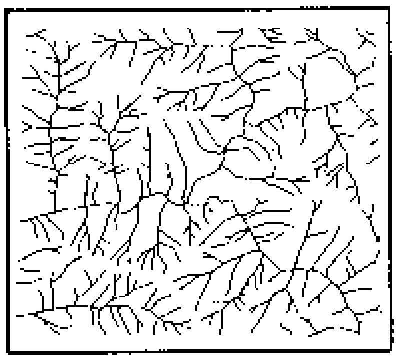
Deadman's Hill
Olympic NF
9.82 mi. / sq. mile
1000 feet (msl)

Mt. Tebo
Olympic NF
6.35 mi. / sq. mile
1800 feet (msl)

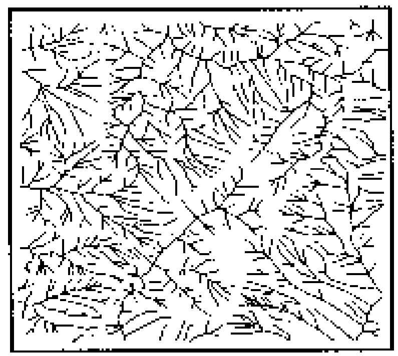
Figure V-G-2. Sample stream density diagrams within the range of the northern spotted owl. (8 pages).

Coast Range (Oregon and Washington)

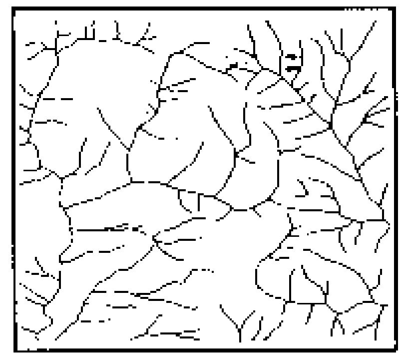
Resistant, other



Kilchis River
BLM/ Siuslaw NF
8.53 mi. / sq. mile
1000 feet (msl)

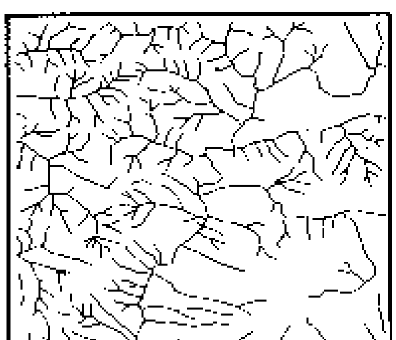


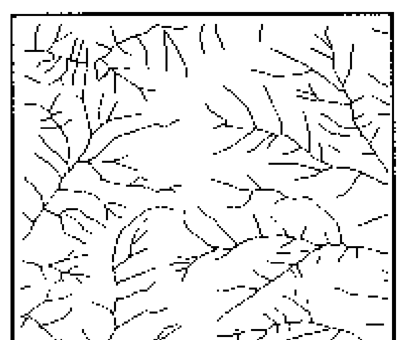
Daniel's Creek
BLM-Medford
12.80 mi. / sq. mile
1000 feet (msl)

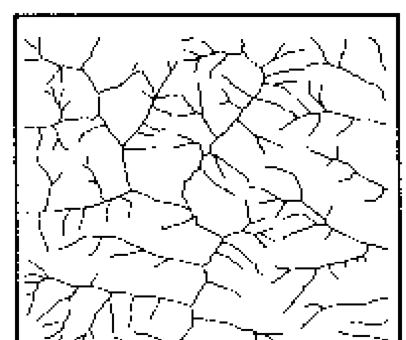


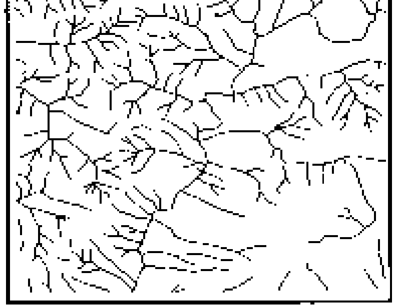
Meacham Corner
BLM-Salem
5.31 mi. / sq. mile
1400 feet (msl)

Resistant sediments

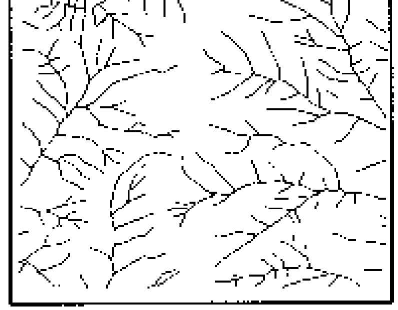




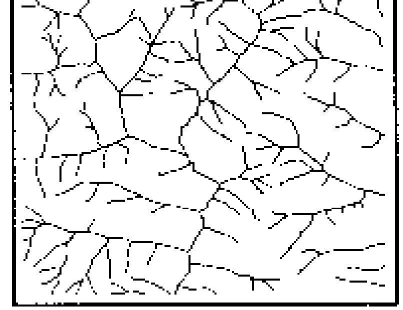




Baldy Mountain
Siuslaw NF
6.94 mi. / sq. mile
1300 feet (msl)

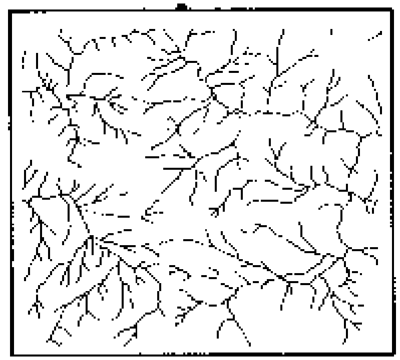


Glenbrook
BLM / Siuslaw NF
5.97 mi. / sq. mile
1230 feet (msl)



Walton
BLM-Eugene
5.48 mi. / sq. mile
900 feet (msl)

Weak rock



Trask Mountain
BLM / Siuslaw NF
6.49 mi. / sq. mile
2200 feet (msl)

North Cascades

Granitic

Intermediate Sediments

Weak Rock

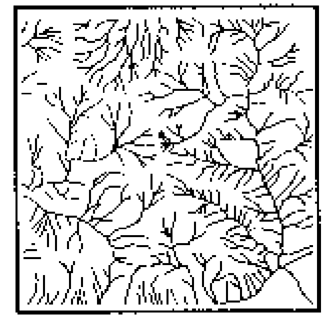
Granitic

Tiffany Mountain
Okanogan NF
3.66 mi. / sq. mile
7000 feet (msl)

Intermediate Sediments

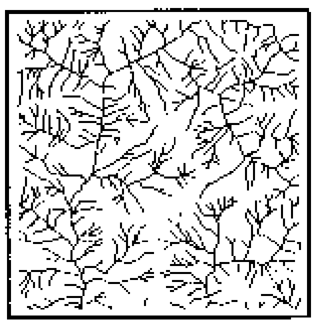
Hoodoo Peak
Okanogan NF
5.68 mi. / sq. mile
4900 feet (msl)

Weak Rock



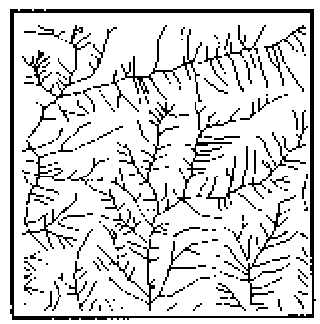
Greenwater
Mt. Baker-Snoqualmie NF
8.93 mi. / sq. mile
2800 feet (msl)

Metamorphic



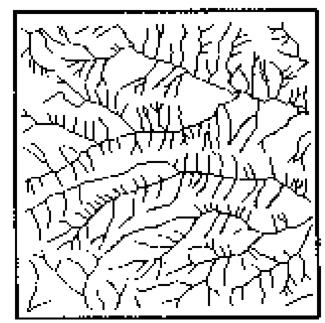
Liberty Lake
Wenatchee NF
9.58 mi. / sq. mile

Sauk Sandstone



Peshastin
Wenatchee NF
8.45 mi. / sq. mile

Pyroclastics



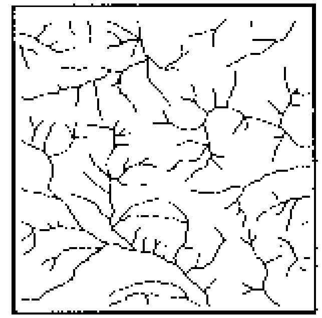
Meeks Table
Wenatchee NF
7.79 mi. / sq. mile

Resistant, other

Resistant, other

Pugh Mountain
Mt. Baker-Snoqualmie NF
6.75 mi. / sq. mile
3700 feet (msl)

Bedal
Mt. Baker-Snoqualmie NF
4.71 mi. / sq. mile
2800 feet (msl)



Frost Mountain
Wenatchee NF
4.66 mi. / sq. mile
4600 feet (msl)

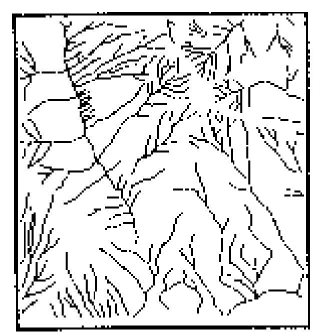
Pyramid Mountain
Wenatchee NF
12.42 mi. / sq. mile
6200 feet (msl)

Western Cascades

Intermediate Sediments

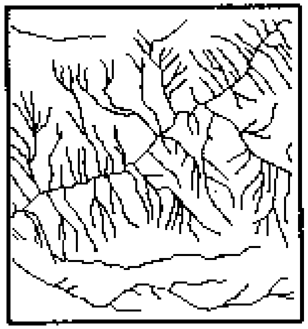
Harrington Creek
BLM - Roseburg
9.21 mi. / sq. mile
2600 feet (msl)

Resistant, other

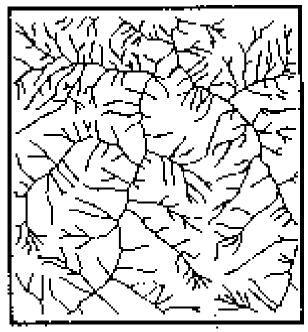


Purcell Mountain

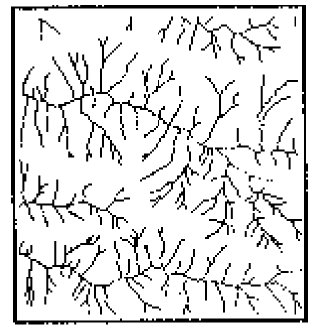
Purcell Mountain
Gifford Pinchot NF
6.92 mi. / sq. mile
3000 feet (msl)



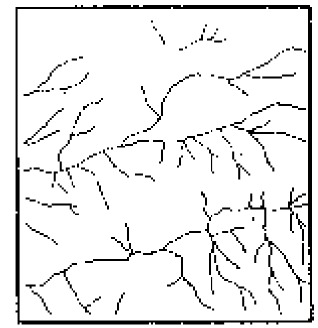
Three Lynx
Mt. Hood NF
6.29 mi. / sq. mile
2900 feet (msl)



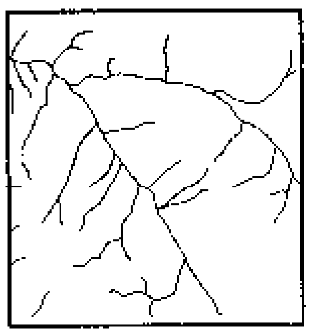
Wanderer's Peak
Mt. Hood NF
7.84 mi. / sq. mile
2800 feet (msl)



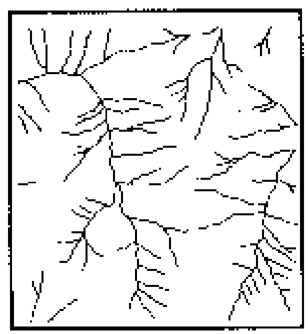
Soosap Peak
Mt. Hood NF / BLM
6.42 mi. / sq. mile
2910 feet (msl)



Brown Mountain
Rogue River NF
3.54 mi. / sq. mile
5000 feet (msl)

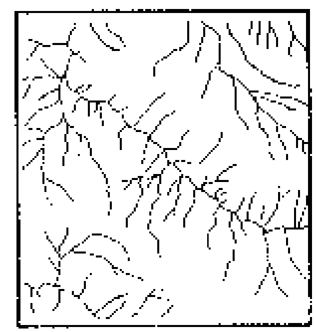


Garwood Butte
Umpqua NF
2.41 mi. / sq. mile
4800 feet (msl)



Grasshopper Mountain
Willamette NF
4.16 mi. / sq. mile
4480 feet (msl)

Coffin Mountain
Willamette NF
5.63 mi. / sq. mile
4000 feet (msl)



Gawley Creek
Willamette NF / BLM
4.58 mi. / sq. mile
2600 feet (msl)

Western Cascades

4800 feet (msl)

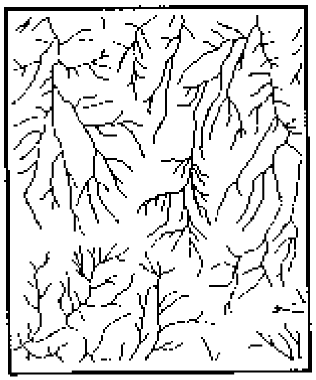
4480 feet (msl)

4000 feet (msl)

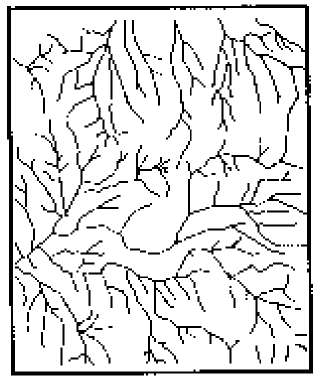
2600 feet (msl)

Western Cascades

Weak Rock



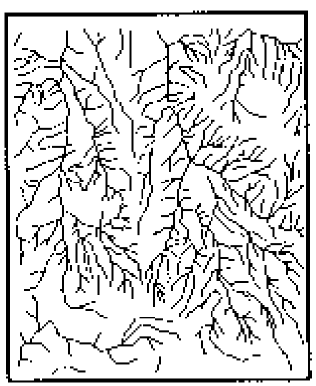
Abbott Butte
Umpqua NF
6.87 mi. / sq. mile
3900 feet (msl)



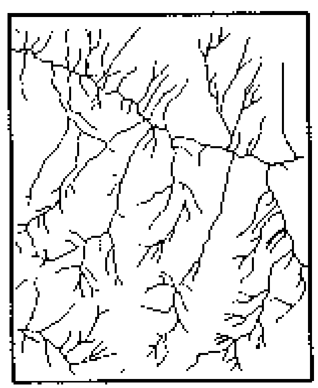
Buckeye Lake
Umpqua NF
6.55 mi. / sq. mile
3600 feet (msl)

Reynold's Ridge
Umpqua NF
8.27 mi. / sq. mile
2440 feet (msl)

Sinker Mountain
Willamette NF
7.75 mi. / sq. mile
2900 feet (msl)

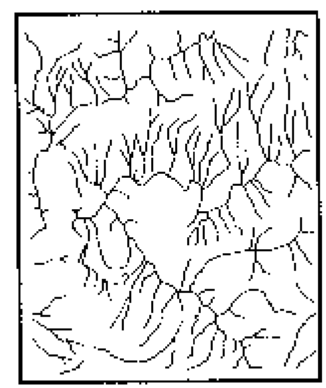


Jordan



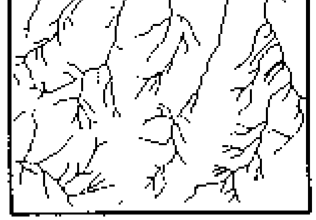
Blue Lake

Smith Creek Butte



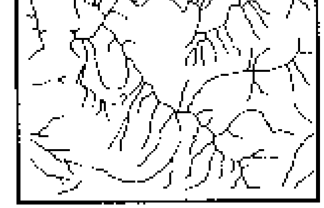
Quartz Creek Butte

Jordan
BLM - Salem
9.58 mi. / sq. mile
1200 feet (msl)



Blue Lake
Gifford Pinchot NF
5.69 mi. / sq. mile
4000 feet (msl)

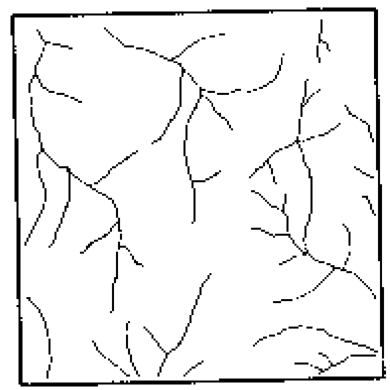
Smith Creek Butte
Gifford Pinchot NF
11.57 mi. / sq. mile
2200 feet (msl)



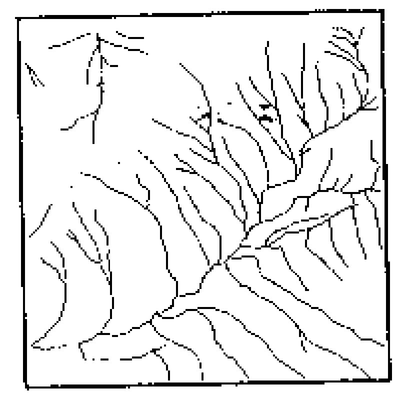
Quartz Creek Butte
Gifford Pinchot NF
6.34 mi. / sq. mile
2300 feet (msl)

High Cascades

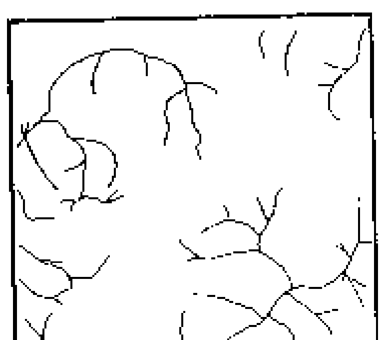
Resistant, other

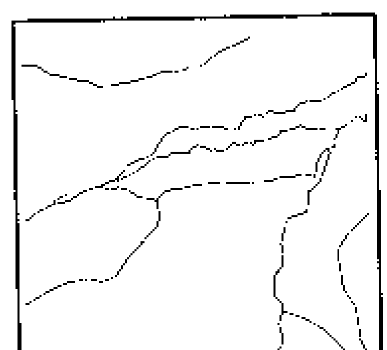


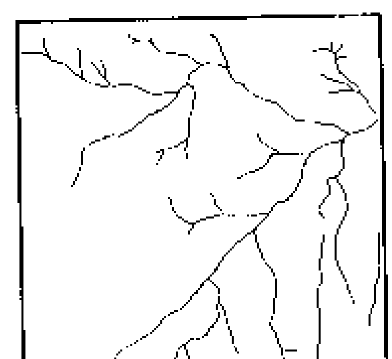
Wolf Peak
Mt. Hood NF
2.66 mi. / sq. mile
4000 feet (msl)



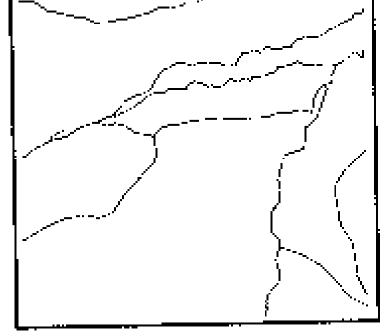
Red Blanket Mountain
Rogue River NF
4.62 mi. / sq. mile
5200 feet (msl)



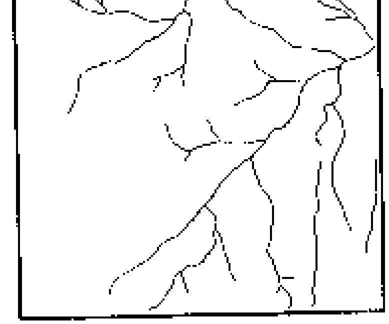




Garner Mountain
Klamath NF
2.42 mi. / sq. mile
6000 feet (msl)

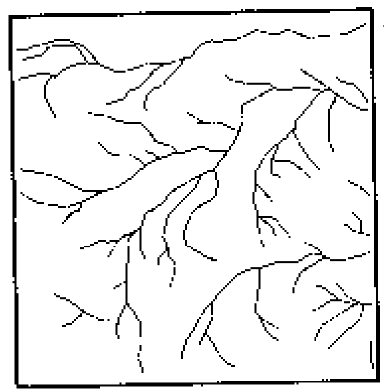


Black Butte
Deschutes NF
1.85 mi. / sq. mile
3160 feet (msl)

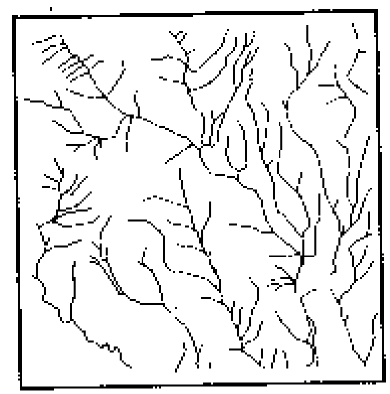


Lake of the Woods-North
Winema NF
2.46 mi. / sq. mile
4750 feet (msl)

Unconsolidated deposits



Sun Pass
Winema NF
3.54 mi. / sq. mile
5300 feet (msl)



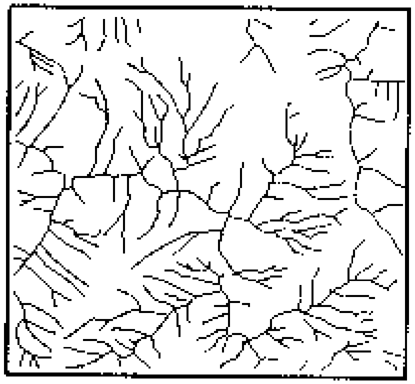
Trout Lake
Gifford Pinchot NF
5.42 mi. / sq. mile
2500 feet (msl)

Franciscan Formation

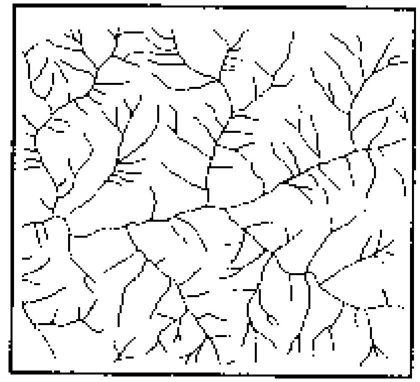
Intermediate Sediments

Franciscan Formation

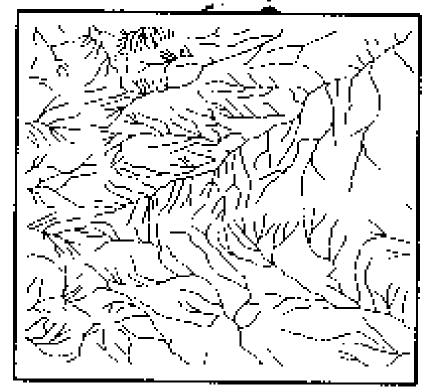
Intermediate Sediments



Quail Prairie Mountain
Siskiyou NF
6.28 mi. / sq. mile
1840 feet (msl)

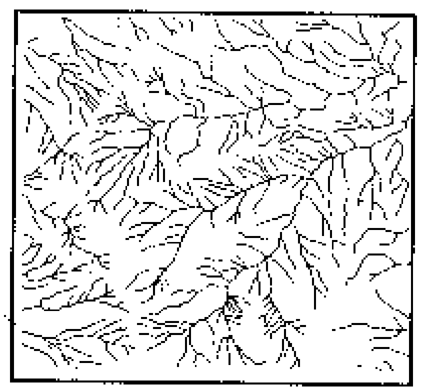


McCullough Creek
BLM - Roseburg
6.27 mi. / sq. mile
1850 feet (msl)



Leech Lake Mountain
Mendicino NF
8.96 mi. / sq. mile
5200 feet (msl)

Weak Rock

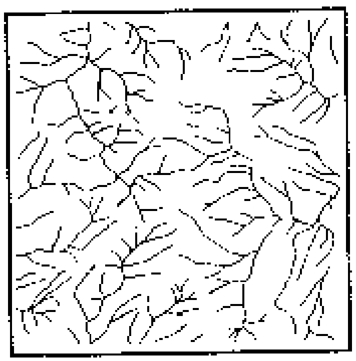


Hull Mountain
Mendicino NF
9.04 mi. / sq. mile
5400 feet (msl)

Hull Mountain
Mendicino NF
9.04 mi. / sq. mile
5400 feet (msl)

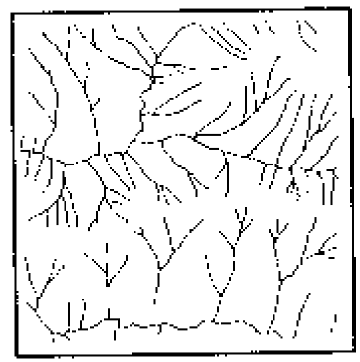
Klamath

Granitic

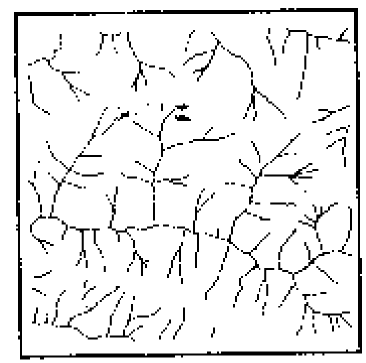


Pony Buck Peak East
Shasta-Trinity NF
6.35 mi. / sq. mile
1400 feet (msl)

Intermediate Sediments

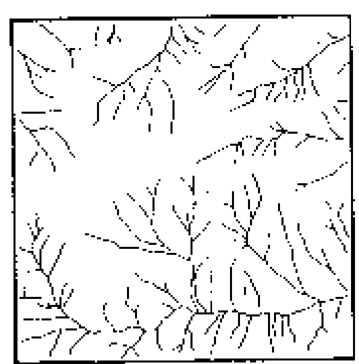


Tish Tang Point
Six Rivers NF
5.13 mi. / sq. mile
2050 feet (msl)



Lonesome Ridge
Six Rivers NF
4.63 mi. / sq. mile
3500 feet (msl)

Resistant, other

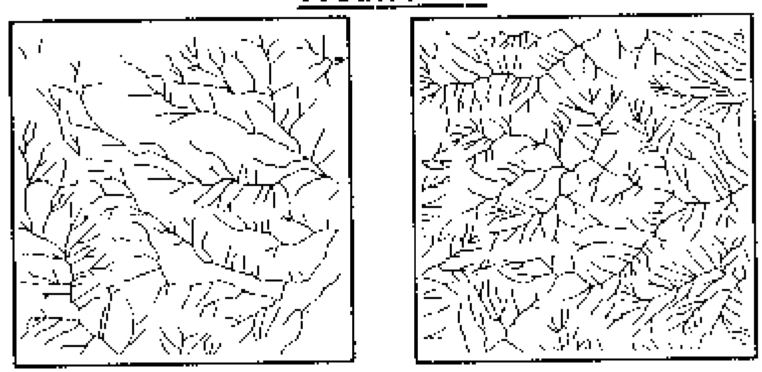


Mt. Peavine
Siskiyou NF
9.67 mi. / sq. mile
2400 feet (msl)

Murphy
BLM - Medford
5.10 mi. / sq. mile
2800 feet (msl)

Del Loma
Shasta-Trinity NF
4.77 mi. / sq. mile
2500 feet (msl)

Weak rock



Happy Camp
Klamath NF
6.69mi. / sq. mile
3200 feet (msl)

Onion Mountain
Siskiyou NF
9.76 mi. / sq. mile
feet (msl)

Table V-G-4. **Calculation of Intermittent Stream Miles based on Drainage Density**

	Forest/BLM Area (ac) **	density factor (km/sq km)	Estimated Area of Lakes/ponds	Miles by stream class I	II	III	Perennial (miles) Fish-bearing	nonfish-bearing	Intermitt. (miles)	Total Stream miles	Note #
DES	1,620,900	1.14	4052	233	170	112	403	112	1,000	1,515	1
GIP	1,371,700	4.44	3429	220	1,620	2,840	1,840	2,840	10,639	15,319	
MBS	1,723,465	4.20	4309	283	524	10,720	807	10,720	6,727	18,254	1
MTH	1,063,450	3.59	2659	400	3,300	4,200	3,700	4,200	1,742	9,642	
OKA	1,706,200	2.88	4266	80	241	603	321	603	11,413	12,337	
OLY	632,324	5.00	1581	336	560	1,277	896	1,277	5,777	7,950	
ROR	632,028	2.52	1580	519	341	566	860	566	2,582	4,008	

	Forest/BLM Area (ac) **	Density factor (km/sq km)	Estimated Area of Lakes/ponds	Miles by stream class I	II	III	Perennial (miles) Fish-bearing	nonfish-bearing	Intermitt. (miles)	Total Stream miles	Note #
DES	1,620,900	1.14	4052	233	170	112	403	112	1,000	1,515	1
GIP	1,371,700	4.44	3429	220	1,620	2,840	1,840	2,840	10,539	15,319	
MBS	1,723,485	4.20	4309	283	524	10,720	807	10,720	6,727	18,254	1
MTH	1,063,450	3.59	2659	400	3,300	4,200	3,700	4,200	1,742	9,642	
OKA	1,706,200	2.88	4266	80	241	603	321	603	11,413	12,337	
OLY	632,324	5.00	1581	336	560	1,277	896	1,277	5,777	7,950	
ROR	632,028	2.52	1580	519	341	566	860	566	2,582	4,008	
SIS	1,092,302	6.30	2731	1,394	1,052	4,044	2,446	4,044	8,087	14,577	2
SIU	631,361	4.31	1578	1,100	100	2,000	1,200	2,000	3,653	6,853	2
UMP	983,889	3.72	2460	343	430	977	773	977	7,447	9,197	
WEN	2,164,180	5.30	5410	805	963	1,795	1,768	1,795	25,245	28,808	
WIL	1,675,407	3.58	4189	421	828	2,001	1,249	2,001	11,825	15,075	
WIN	1,043,547	1.85	2609	60	130	110	190	110	1,000	1,300	1
KLA	1,680,282	3.22	4201				1,195	2,675	9,736		3
SH-T	2,121,547	3.64	5304				1,900	745	16,752		3
SIX	958,470	3.64	2396				850	1,109	6,810		3
MEND	894,339	5.56	2236				319	1,127	11,042		3
	NOTE: for analysis purposes, Ken Wright adjusted total stream length for CA forests										
BLM-Eug	316,590	3.65					640	963	1303		2
BLM-Med	866,323	3.54					531	1617	5781		
BLM-Salem	393,512	3.80					776	820	2165		
BLM-Ros	419,410	3.50					1028	646	2017		
BLM-KFalls	39,413	0.98					23	29	45		
BLM-Coos	329,588	4.23					556	1695	1254		
BLM-Ukiah	16,012	4.45					168	305	324		

Column.. 1: Forest/District area per Forest Plans or C.Novak
2: Total stream density from USGS quad "window" exercise
3: Area of lakes/ponds/wetlands outside of RHCAs... estimated as 0.25% of total Forest area
4: Miles by FS Stream Class per Forest or from 1984 table
5: Miles by FS Stream Class per Forest or from 1984 table
6: Miles by FS Stream Class per Forest or from 1984 table
7: miles of Class I-II from Forests (R6); perennial fish-bearing from R5 and BLM
8: miles of Class III from Forests (R6); perennial nonfish-bearing from R5 and BLM
9: [(col. 1) * (col. 2)] - [(col. 6) + (col. 7)]... adjusted as noted and with correct units

Note 1: estimated by professional judgement
Note 2: estimated from other coastal forests
Note 3: Forest acres per Ken Wright

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Appendix H

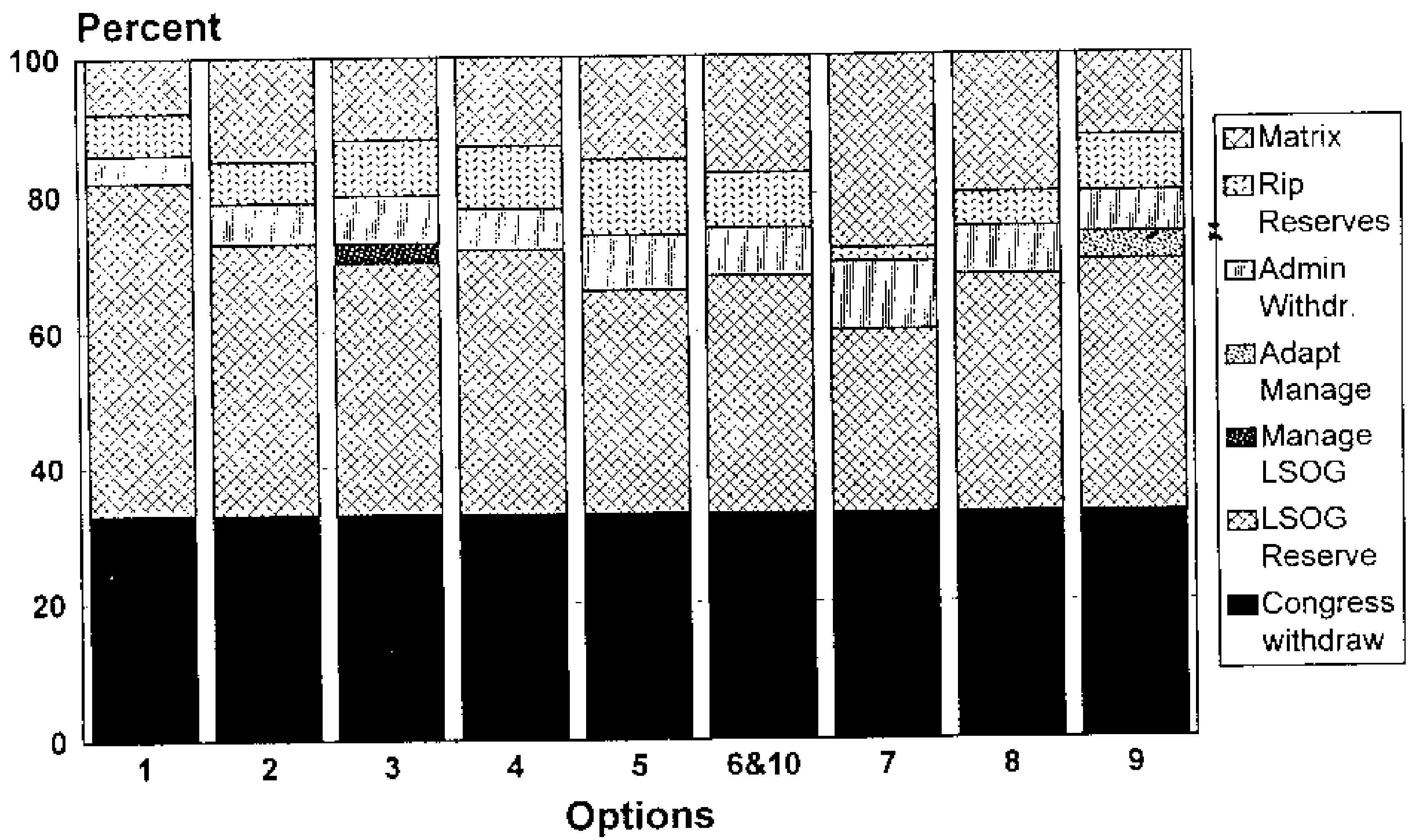


Figure V-H-1. Percent of Tier 1 Key Watersheds by forest allocation under each forest management option

Figure V-H-1. Percent of Tier 1 Key Watersheds by forest allocation under each forest management option

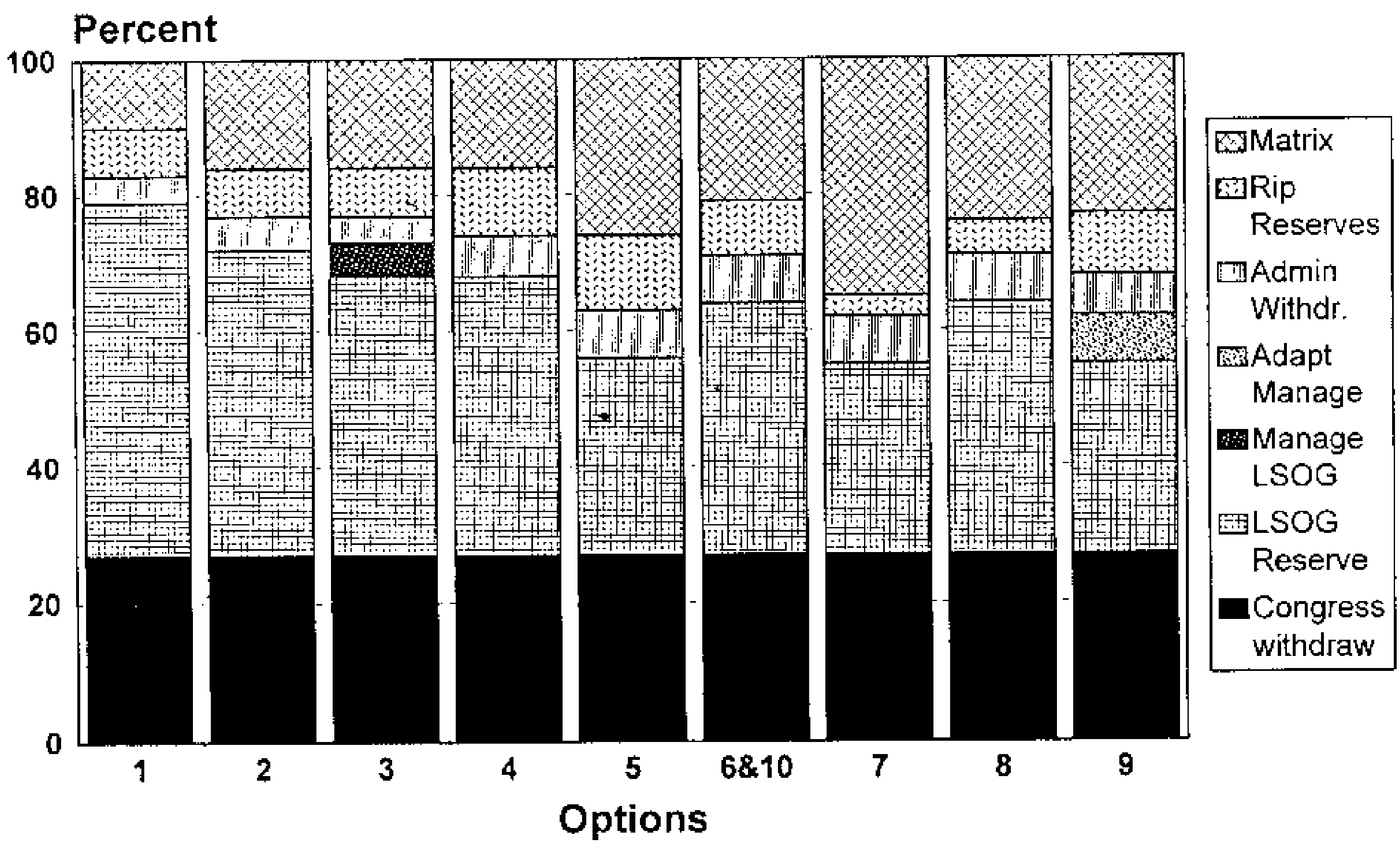


Figure V-H-2. Percent of Tier 2 Key Watersheds by forest allocation under each forest management option.

Figure V-H-2. Percent of Tier 2 Key Watersheds by forest allocation under each forest management option.

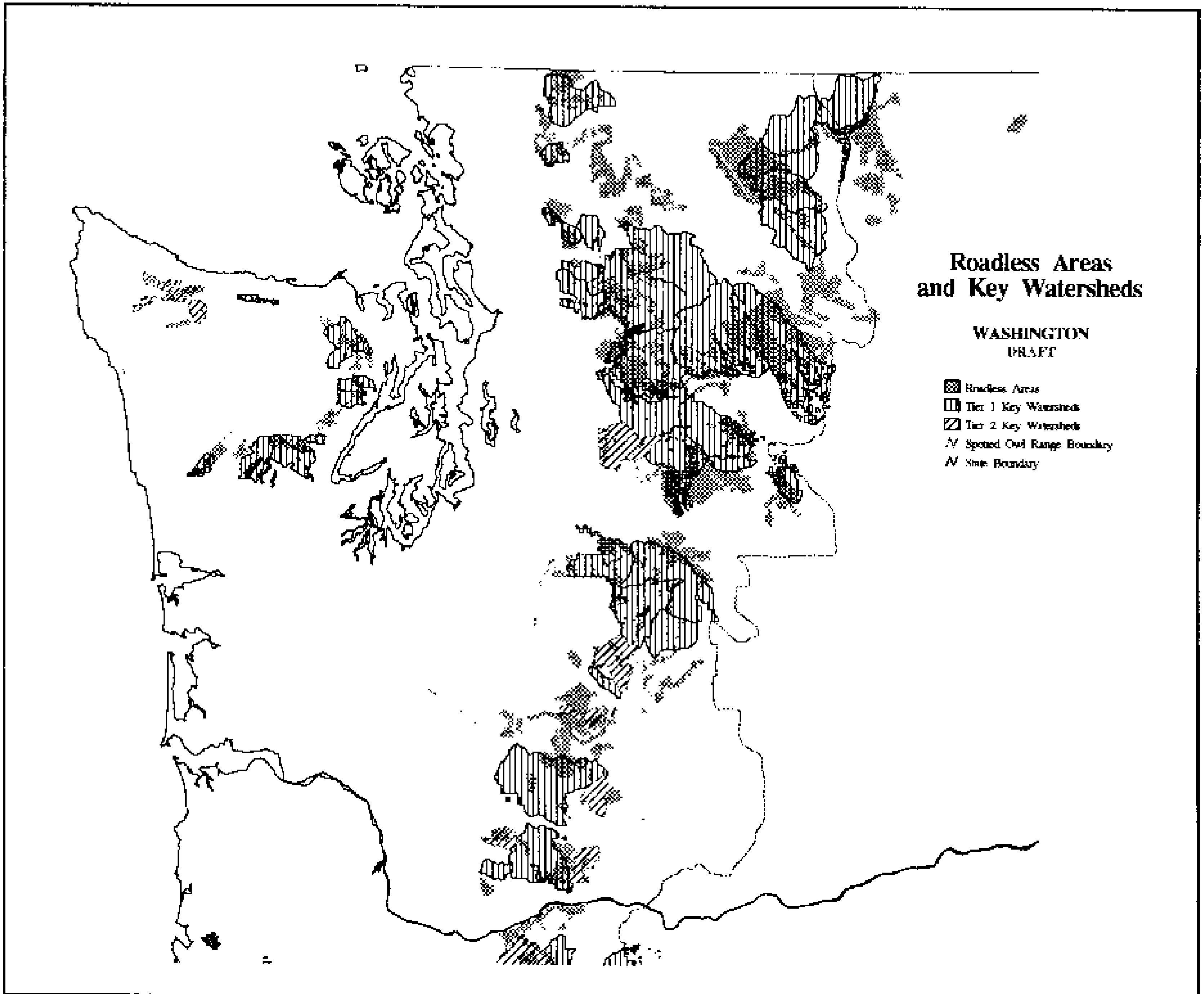
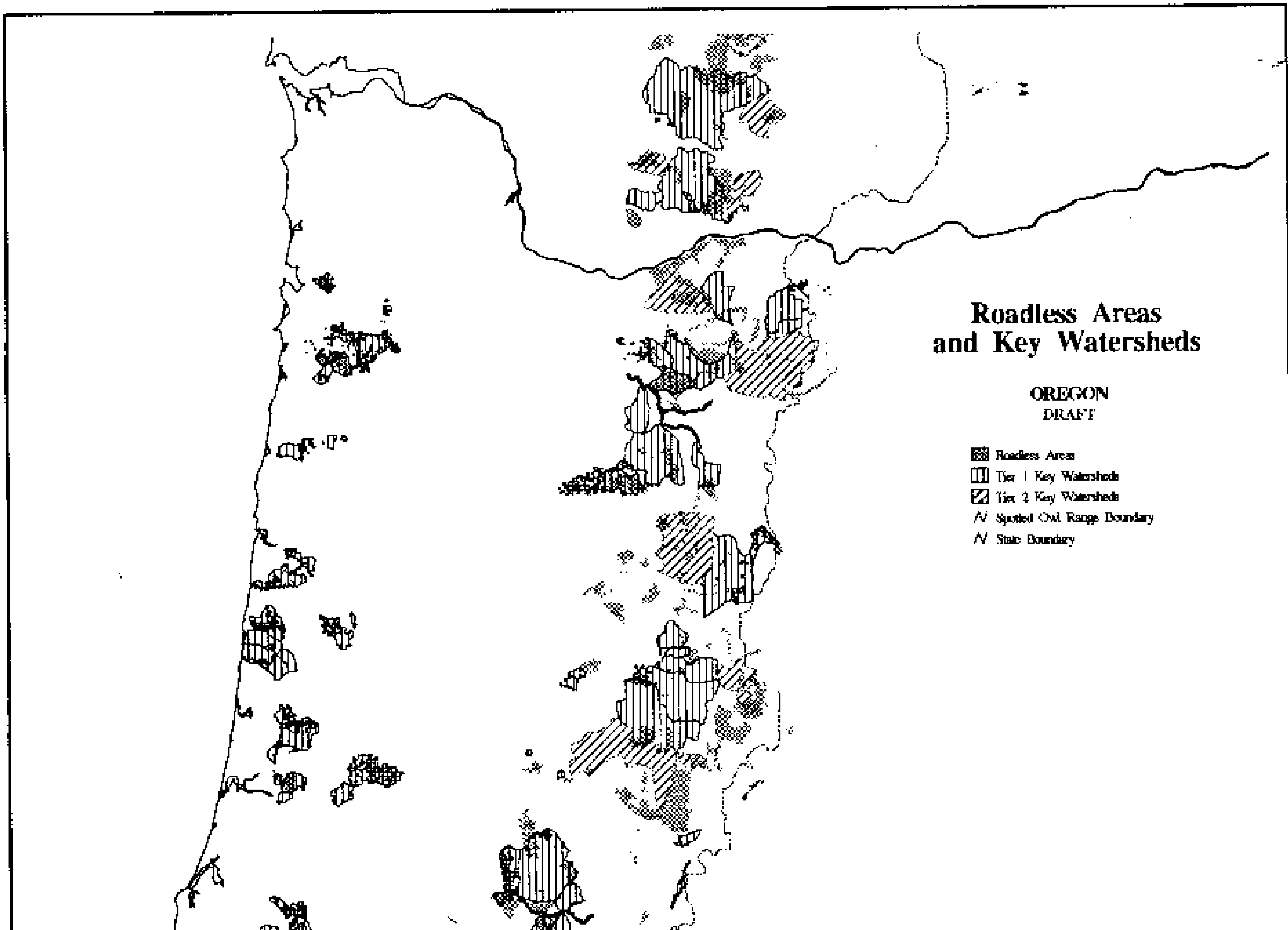


Figure V-H-3. Washington roadless areas and Key

Figure V-H-3. Washington roadless areas and Key Watersheds. Roadless areas shown are those that were inventoried during the Roadless Area Review and Evaluation (RARE II) process and remain in roadless condition.



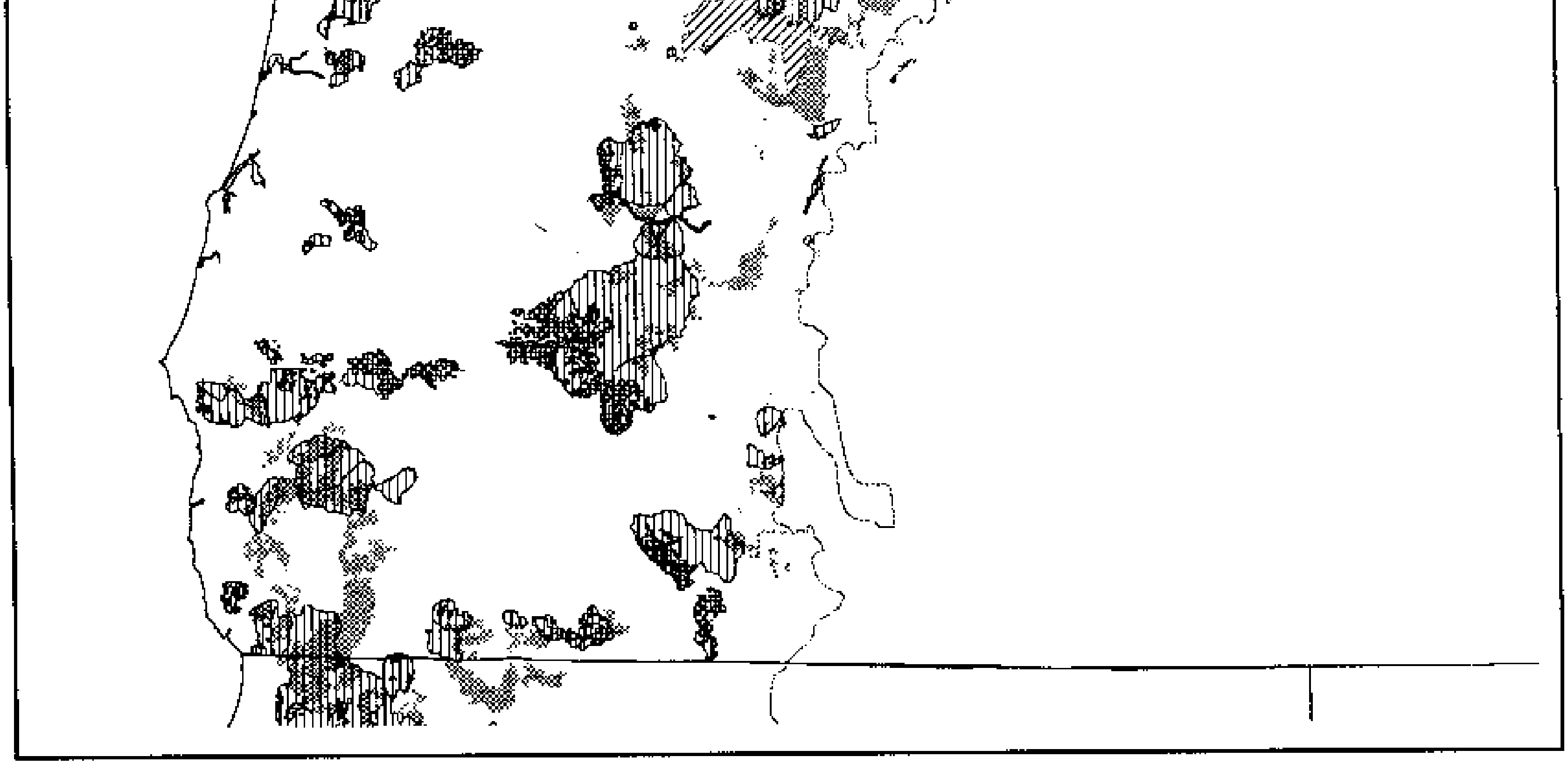
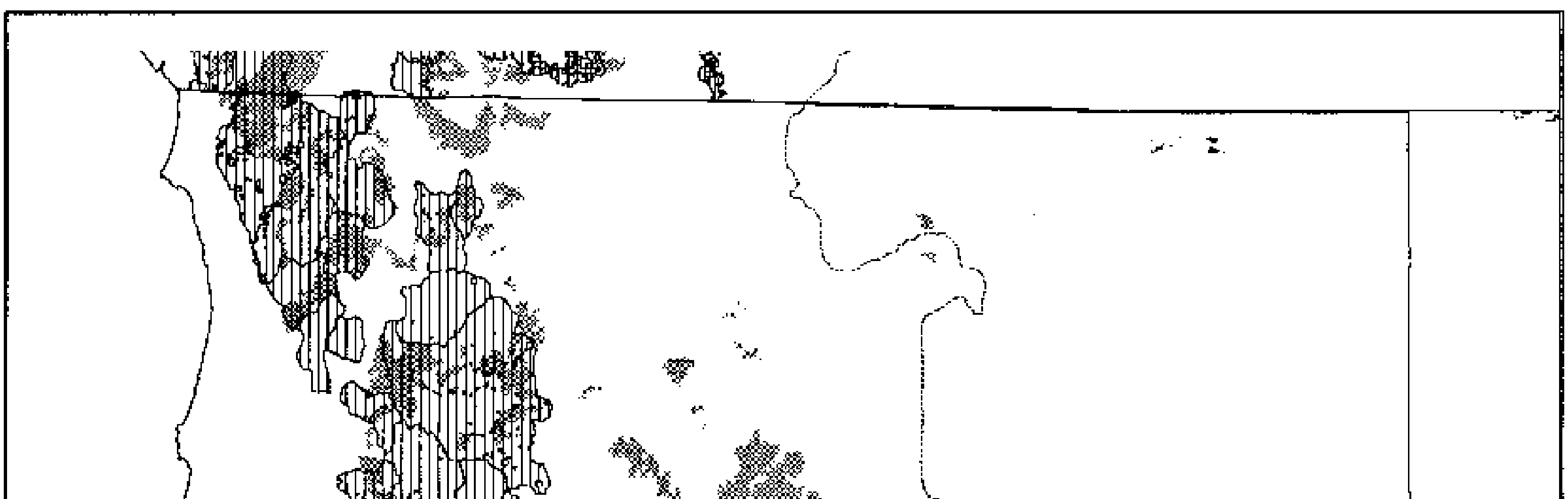
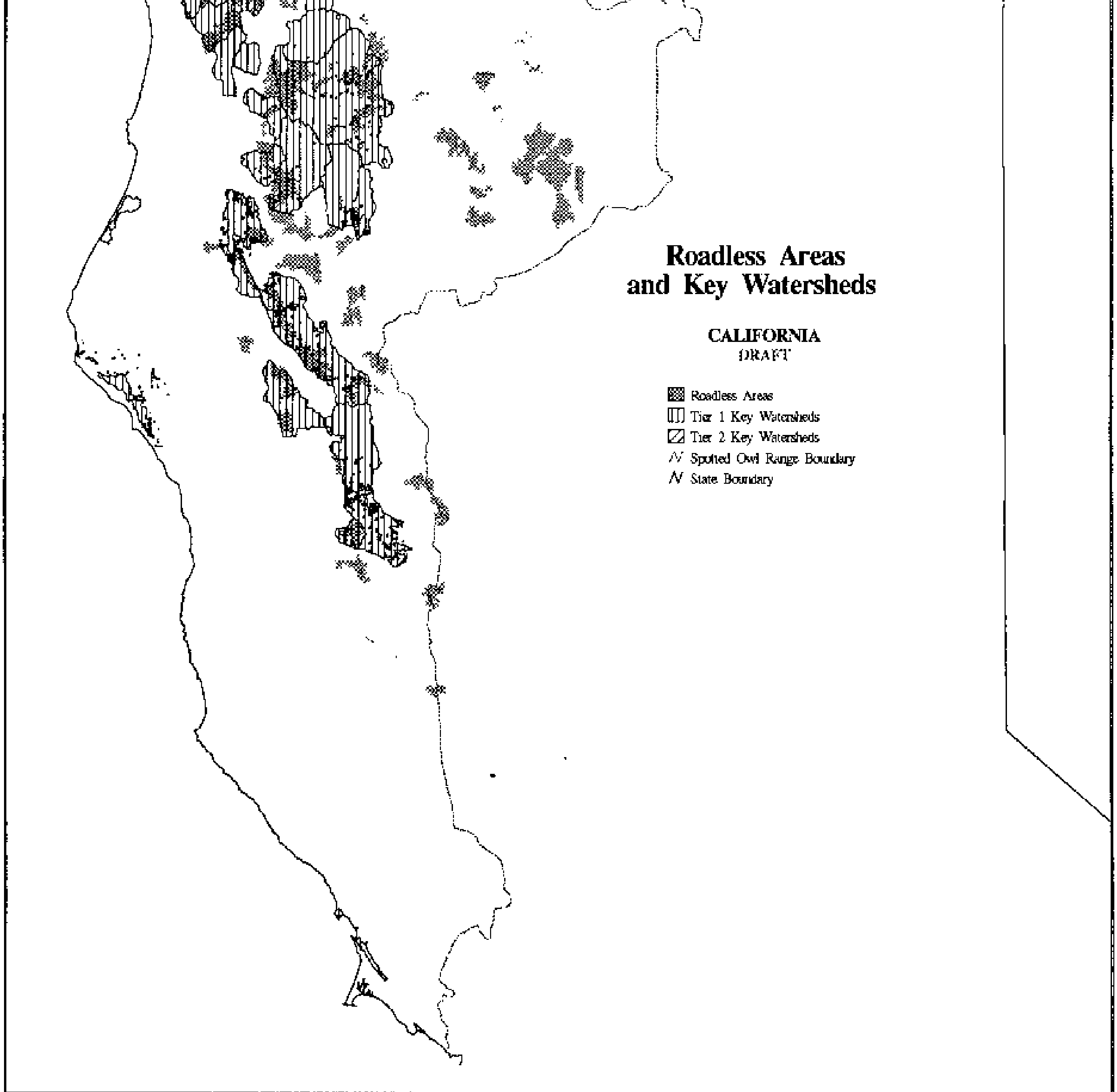


Figure V-H-4. Oregon roadless areas and Key Watersheds. Roadless areas shown are those that were inventoried during the Roadless Area Review and Evaluation (RARE II) process and remain in roadless condition.




Roadless Areas
and Key Watersheds
CALIFORNIA
DRAFT
Roadless Areas
Tier 1 Key Watersheds
Tier 2 Key Watersheds
Spotted Owl Range Boundary
State Boundary

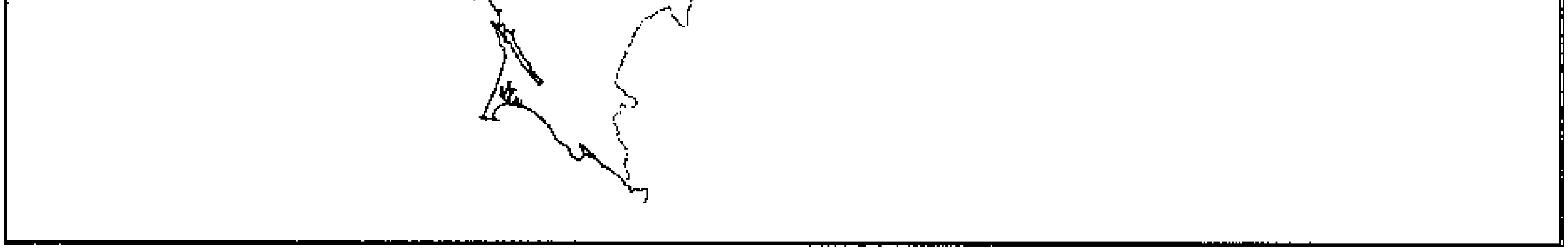


Figure V-H-5. California roadless areas and Key Watersheds. Roadless areas shown are those that were inventoried during the Roadless Area Review and Evaluation (RARE II) process and remain in roadless condition.

Table V-H-1. Key Watersheds.

Watershed Tier	River/Key Watershed		National Forest	BLM District
	WASHINGTON			
	Puyallup R.			
1	WF-23	White R.	Mt. Baker-Snoqualmie	
	Snohomish R.			
1	WF-25	Skykomish R.	Mt. Baker-Snoqualmie	
	Snoqualmie R.			
2	WF-24	M.Fk. Snoqualmie R.	Mt. Baker-Snoqualmie	
	Stillaguamish R.			
1	WF-27	Deer Cr.	Mt. Baker-Snoqualmie	
1	WF-28	N.Fk. Stillaguamish R.	Mt. Baker-Snoqualmie	
1	WF-26	S.Fk. Stillaguamish R.	Mt. Baker-Snoqualmie	
	Skagit R.			
1	WF-29	Sauk R.	Mt. Baker-Snoqualmie	
1	WF-30	Suiattle R.	Mt. Baker-Snoqualmie	
	Nooksack R.			
1	WF-31	S.Fk. Nooksack R.	Mt. Baker-Snoqualmie	
1	WF-32	N.Fk. Nooksack R.	Mt. Baker-Snoqualmie	
	Columbia R.			

1	WF-30	Suiattle R.	Mt. Baker-Snoqualmie
	Nooksack R.		
1	WF-31	S.Fk. Nooksack R.	Mt. Baker-Snoqualmie
1	WF-32	N.Fk. Nooksack R.	Mt. Baker-Snoqualmie
	Columbia R.		
1	WF-1	Wind R.	Gifford Pinchot
2	WF-5	White Salmon R.	Gifford Pinchot
2	WF-3	Little White Salmon R.	Gifford Pinchot
	Lewis R.		
1	WF-2	E.Fk. Lewis R.	Gifford Pinchot
2	WF-4	Siouxon Cr.	Gifford Pinchot
1	WF-6	Lewis R.	Gifford Pinchot
	Cowlitz R		
2	WF-8	N.Fk. Cispus R.	Gifford Pinchot
2	WF-10	Clear Fk. Cowlitz R.	Gifford Pinchot
2	WF-7	Upper Cispus R.	Gifford Pinchot
1	WF-9	Packwood Lake & associated streams	Gifford Pinchot
	Methow R.		
1	WF-20	Twisp R.	Okanogan
1	WF-21	Early Winters Cr./Upper Methow R.	Okanogan
1	WF-22	Chewach R.	Okanogan
	Chelalis R.		
1	WF-33	Wynoochie R.	Olympic
1	WF-34	Satsop R./Canyon R.	Olympic
	Quillaute R.		
2	WF-40	Soleduck R.	Olympic
	Quinault R.		
1	WF-41	Cook Cr./McCalla Cr.	Olympic
	Strait of Juan de Fuca		
1	WF-38	Dungeness R.	Olympic
1	WF-39	Elwha R.	Olympic

	Quinault R.			
1	WF-41	Cook Cr./McCalla Cr.	Olympic	
	Strait of Juan de Fuca			
1	WF-38	Dungeness R.	Olympic	
1	WF-39	Elwha R.	Olympic	

Table V-H-1. (Continued)

Watershed Tier	River/Key Watershed		National Forest	BLM District
	Hood Canal			
1	WF-35	Skokomish R.	Olympic	
1	WF-42	Lake Cushman/N.Fk. Skok. tribs	Olympic	
1	WF-36	Duckabush R.	Olympic	
1	WF-37	Dosewallips R.	Olympic	
	Quilcene R.			
2	WF-43	L. Quilcene R.	Olympic	
	Columbia R.			
	Yakima R.			
1	WF-11	Naches R./Little Naches R.	Wenatchee	
1	WF-12	Rattlesnake Cr.	Wenatchee	
1	WF-13	Bumping-American R.	Wenatchee	
1	WF-14	Cle Elum R.	Wenatchee	
	Wenatchee R.			
1	WF-15	Ingalis Cr.	Wenatchee	
1	WF-16	Mission Cr.	Wenatchee	
1	WF-17	Icicle Cr.	Wenatchee	
1	WF-18	Upper Wenatchee R.	Wenatchee	
	Entiat R.			
1	WF-19	Entiat R.	Wenatchee	

OREGON

1	WF-17	Icicle Cr.	Wenatchee	
1	WF-18	Upper Wenatchee R.	Wenatchee	
	Entiat R.			
1	WF-19	Entiat R.	Wenatchee	
	OREGON			
	Pacific Ocean			
1	OF-44	Winchuck R.	Siskiyou	
1	OF-57	Elk R.	Siskiyou	
	Smith R.			
1	OF-45	Baldface Cr./N.Fk. Smith R.		
	Chetco R.			
1	OF-46	Emily Cr.	Siskiyou	
1	OB-47	N.Fk. Chetco R.		Coos Bay
	Rogue R.			
1	OF-48	Taylor Cr.	Siskiyou	
1	OF-49	Quosatana Cr.	Siskiyou	
1	OF-50	Shasta-Costa Cr.	Siskiyou	
	Illinois R.			
1	OF-51	Grayback Cr./Cave Cr.	Siskiyou	
1	OF-52	Upper Sucker Cr.	Siskiyou	
1	OF-53	Upper E.Fk. Illinois R.	Siskiyou	
1	OF-54	Lawson Cr.	Siskiyou	
1	OU-55	Silver Cr.	Siskiyou	Medford
1	OF-56	Indigo Cr.	Siskiyou	
	Sixes R.			
1	OF-58	Dry Cr.	Siskiyou	

Table V-H-1. (Continued)

Watershed Tier	River/Key Watershed		National Forest	BLM District

Table V-H-1. (Continued)

Watershed Tier	River/Key Watershed		National Forest	BLM District
	Coquille R.			
1	OU-59	S.Fk. Coquille R.	Siskiyou	Coos Bay
1	OB-60	Cherry Cr. (E.Fk. Coquille)		Coos Bay
1	OB-61	N.Fk. Coquille R.		Coos Bay
	Coos R.			
1	OB-62	Tioga Cr.		Coos Bay
	Lower Umpqua R.			
1	OF-63	Franklin Cr.	Siuslaw	
1	OB-64	Paradise Cr.		Coos Bay
	Smith R.			
1	OF-65	Wassen Cr.	Siuslaw	
1	OF-66	N.Fk. Smith R.	Siuslaw	
1	OB-67	Upper Smith R.		Roseburg
	Siuslaw R.			
1	OF-68	N.Fk. Siuslaw R.	Siuslaw	
1	OF-69	W.Fk. Indian Cr.	Siuslaw	
1	OF-70	Sweet Cr.	Siuslaw	
	Pacific Ocean			
1	OF-71	Cummins/Tenmile/Rock/Big Crs.	Siuslaw	
1	OF-72	Yachats R.	Siuslaw	
	Alsea R.			
1	OU-73	Drift Cr. (Alsea)	Siuslaw	Salem
1	OB-74	Tobe Cr.		Salem
1	OB-75	Lobster Cr.		Salem
	Yaquina R.			
1	OF-76	Mill Cr.	Siuslaw	

1	OU-73	Drift Cr. (Alsea)	Siuslaw	Salem
1	OB-74	Tobe Cr.		Salem
1	OB-75	Lobster Cr.		Salem
	Yaquina R.			
1	OF-76	Mill Cr.	Siuslaw	
	Siletz R./Bay			
1	OU-77	Drift Cr. (Siletz)	Siuslaw	Salem
1	OB-78	N.Fk. Siletz R./Warnick Cr.		Salem
	Nestucca R.			
1	OB-79	Nestucca R.	(Siuslaw)	Salem
1	OF-80	Three Rivers	Siuslaw	
1	OF-81	Powder Cr./Niagara Cr.	Siuslaw	
1	OF-82	Limestone Cr./Boulder Cr./Tony Cr.	Siuslaw	
	Tillamook Bay			
1	OB-83	Kilchis R.		Salem
1	OB-84	Little N.Fk. Wilson R.		Salem
	Trask R.			
1	OB-85	M.Fk. Trask R./Elkhorn Cr.		Salem

Table V-H-1. (Continued)

Watershed Tier	River/Key Watershed		National Forest	BLM District
	Umpqua R.			
	S. Umpqua R.			
1	OU-86	S. Umpqua R.	Umpqua	Roseburg
	Cow Cr.			
1	OB-93	W.Fk. Cow Cr.		
1	OB-94	Middle Cr.		
	N. Umpqua R.			
1	OF-87			

	[illegible]	S. Umpqua R.	Umpqua	Roseburg
	Cow Cr.			
1	OB-93	W.Fk. Cow Cr.		
1	OB-94	Middle Cr.		
	N. Umpqua R.			
1	OF-87	Calf Cr.	Umpqua	
1	OF-88	Copeland Cr.	Umpqua	
1	OF-89	Boulder Cr.	Umpqua	
1	OU-90	Steamboat Cr. (inc. Canton & Pass Crs.	Umpqua	Roseburg
1	OF-91	Deception Cr./ Wilson Cr.	Umpqua	
1	OF-92	N. Umpqua R. Corridor (Steamboat Cr. to Deer Cr.)	Umpqua	
	Rogue R.			
1	OU-96	Elk Cr.	Rogue River	Medford
1	OU-97	S.Fk./N.Fk. Little Butte Cr.	Rogue River	Medford
	Applegate R.			
1	OF-98	Palmer Cr.	Rogue River	
1	OF-99	Beaver Cr.	Rogue River	
1	OF-100	Yale Cr.	Rogue River	
1	OF-101	Little Applegate R.	Rogue River	
	Klamath R.			
1	OB-102	Jenny Cr.		Medford
2	OF-103	Clover Cr.	Winema	
2	OF-104	Rainbow Cr.	Winema	
2	OF-105	Pelican Butte	Winema	
1	OF-106	Cherry Cr.	Winema	
1	OF-107	Seven Mile Cr.	Winema	
1	OF-108	Evening Cr.	Winema	
	Columbia R.			

1	OF-106	Cherry Cr.	Winema	
1	OF-107	Seven Mile Cr.	Winema	
1	OF-108	Evening Cr.	Winema	
	Columbia R.			
	Willamette R.			
	M.Fk. Willamette R.			
1	OF-109	Fern Cr.-Shady Del	Willamette	
2	OF-110	N.Fk. of the M.Fk. Willamette R.	Willamette	
	Santiam R.			
	N. Santiam R.		Willamette	
2	OF-110	Upper N. Santiam R.	Willamette	
1	OU-111	Upper Little N. Santiam R.	Willamette	Salem

Table V-H-1. (Continued)

Watershed Tier	River/Key Watershed		National Forest	BLM District
	Mckenzie R.			
1	OF-112	S. Fk. Mckenzie R.	Willamette	
1	OF-113	Horse Cr.	Willamette	
1	OF-114	Lost Cr./Scott Cr.	Willamette	
1	OF-115	Boulder Cr.	Willamette	
1	OF-116	Upper Mckenzie R.	Willamette	
1	OB-117	Lower McKenzie tribs (Marten, Bear)		Eugene
	Columbia R.			
1	OF-118	Fifteen Mile Cr./Ramsey Cr.	Mt. Hood	
1	OF-119	W.Fk. Hood R.	Mt. Hood	
1	OF-120	Mill Cr./Five Mile Cr./Eight Mile Cr.	Mt. Hood	
	Clackamas R.			
1	OF-121	Clackamas R. Corridor (Big Cliff	Mt. Hood	

1	OF-118	Fifteen Mile Cr./Ramsey Cr.	Mt. Hood	
1	OF-119	W.Fk. Hood R.	Mt. Hood	
1	OF-120	Mill Cr./Five Mile Cr./Eight Mile Cr.	Mt. Hood	
	Clackamas R.			
1	OF-121	Clackamas R. Corridor (Big Cliff to Clackamas headwaters)	Mt. Hood	
1	OF-122	Collowash R.	Mt. Hood	
1	OF-123	Fish Cr.	Mt. Hood	
1	OF-124	Oak Grove Fk. Corridor (Clackamas R. to Timothy Lake)	Mt. Hood	
1	OF-125	Roaring R.	Mt. Hood	
1	OU-126	Eagle Cr.	Mt. Hood	Salem
	Sandy R.			
1	OU-127	Salmon R.	Mt. Hood	Salem
2	OF-128	Bull Run R.	Mt. Hood	
	Deschutes R.			
2	OF-129	White R.	Mt. Hood	
1	OF-130	Big Marsh Cr.	Deschutes	
1	OF-131	Odell Cr.	Deschutes	
2	OF-132	Deschutes R. Corridor (Lava Lake to Crane Prairie)	Deschutes	
2	OF-133	Cultus Cr.	Deschutes	
2	OF-134	Deschutes R. Corridor (Dilman Meadows to La Pine Rec. Area)	Deschutes	
2	OF-135	Deschutes R. Corridor (Benham Falls Camp to Dillon Falls)	Deschutes	
2	OF-136	Tumalo Cr.	Deschutes	
2	OF-137	Squaw Cr.	Deschutes	
1	OF-138	Metolius R.	Deschutes	
2	OF-139	Three Creeks Meadows and Creek	Deschutes	

		Falls Camp to Dillon Falls)		
2	OF-136	Tumalo Cr.	Deschutes	
2	OF-137	Squaw Cr.	Deschutes	
1	OF-138	Metolius R.	Deschutes	
2	OF-139	Three Creeks Meadows and Creek	Deschutes	
	CALIFORNIA			
	Eel R.			
1	CF-140	Thatcher Cr.	Mendocino	
1	CF-141	Black Butte Cr.	Mendocino	
1	CF-142	M.Fk. Eel R.	Mendocino	

Table V-H-1. (Continued)

Watershed Tier	River/Key Watershed		National Forest	BLM District
	Klamath R.			
	Trinity R.			
1	CF-143	N.Fk. Trinity R.	Shasta-Trinity	
1	CF-144	Canyon Cr.	Shasta-Trinity	
1	CF-145	S.Fk. Trinity R.	Shasta-Trinity	
1	CF-146	New River	Shasta-Trinity	
	Eel R.			
1	CF-147	N.Fk. Eel R.	Six Rivers	
	Mad R.			
1	CF-148	Pilot Cr.	Six Rivers	
	Klamath R.			
1	CF-149	Red Cap Cr.	Six Rivers	
1	CF-150	Bluff Cr.	Six Rivers	
1	CF-151	Blue Cr.	Six Rivers	
1	CF-152	Camp Cr.	Six Rivers	

	Klamath R.			
1	CF-149	Red Cap Cr.	Six Rivers	
1	CF-150	Bluff Cr.	Six Rivers	
1	CF-151	Blue Cr.	Six Rivers	
1	CF-152	Camp Cr.	Six Rivers	
	Trinity R.			
1	CF-153	Lower S.Fk. Trinity R.	Six Rivers	
1	CF-154	Horse Linto Cr.	Six Rivers	
	Pacific Ocean			
1	CF-155	Smith R.	Six Rivers	
	Klamath R.			
1	CF-156	Salmon R.	Klamath	
1	CF-157	Wooley Cr.	Klamath	
1	CF-158	Elk Cr.	Klamath	
1	CF-159	Dillon Cr.	Klamath	
1	CF-160	Clear Cr.	Klamath	
1	CF-161	Grider Cr.	Klamath	
	Mattole R.			
1	CB-162	Honeydew/Bear Cr.		Ukiah

Table V-II-2. Percentage of Tier 1 Key Watersheds by forest management allocation by option by state and physiographic province.

			OPTION 1				OPTION 2				OPTION 3				
			Percent of key watershed in:				Percent of key watershed in:				Percent of key watershed in:				
State/ Physiographic province	Total acres federal land	Congress Withdrawn Areas	Late Succession Reserves	Admin. Withdrawn Areas	Riparian Reserves	Matrix	Late Succession Reserves	Admin. Withdrawn Areas	Riparian Reserves	Matrix	Late Succession Reserves	Managed Late-Succession Reserves	Admin. Withdrawn Areas	Riparian Reserves	Matrix
Washington															
Eastern Cascades	3,472,400	46	33	7	5	10	27	8	5	15	30	0	7	6	11
Western Cascades	3,721,700	37	47	5	4	6	42	8	4	10	40	1	9	5	8
Western Lowlands	126,300	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Olympic Peninsula	1,518,800	22	61	0	9	8	60	0	8	11	60	0	0	9	9
Total:	8,839,200	40	41	6	5	8	36	7	5	12	36	1	8	6	10

province	federal land	Areas	Reserves	Areas	Reserves	Matrix	Reserves	Areas	Reserves	Matrix	Reserves	Reserves	Areas	Reserves	Matrix
Washington															
Eastern Cascades	3,472,400	46	33	7	5	10	27	8	5	15	30	0	7	6	11
Western Cascades	3,721,700	37	47	5	4	6	42	8	4	10	40	1	9	5	8
Western Lowlands	126,300	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Olympic Peninsula	1,518,800	22	61	0	9	8	60	0	8	11	60	0	0	9	9
Total:	**8,839,200**	**40**	**41**	**6**	**5**	**8**	**36**	**7**	**5**	**12**	**36**	**1**	**8**	**6**	**10**
Oregon															
Klamath	2,106,200	8	74	2	7	9	65	3	9	15	61	3	4	10	14
Eastern Cascades	1,557,400	23	55	3	7	12	51	4	5	17	55	0	3	7	12
Western Cascades	4,478,200	23	60	1	7	9	48	2	9	18	37	11	3	12	15
Coast Range	1,396,800	6	79	0	7	7	45	9	7	21	75	0	0	9	10
Willamette Valley	25,600	0	0	0	56	56	0	0	0	0	0	0	0	56	56
Total:	**9,564,200**	**17**	**66**	**1**	**7**	**9**	**47**	**2**	**7**	**15**	**50**	**6**	**3**	**11**	**14**
California															
Coast Range	388,200	18	53	9	7	13	73	0	8	13	45	0	9	10	17
Klamath	4,459,900	41	43	4	5	7	27	9	7	16	24	2	11	10	13
Cascades	1,009,200	0	0	0	0	0	0	0	28	56	0	0	0	0	0
Total:	**5,857,300**	**40**	**43**	**5**	**5**	**7**	**39**	**9**	**8**	**17**	**24**	**2**	**11**	**10**	**13**
Three-State Total:	**24,260,700**	**33**	**49**	**4**	**6**	**8**	**40**	**6**	**6**	**15**	**37**	**3**	**7**	**8**	**12**

State/ Physiographic province	Total acres federal land	Congress Withdrawn Areas	OPTION 4 Percent of key watershed in: Late Succession Reserves*	Admin. Withdrawn Areas	Riparian Reserves	Matrix	OPTION 5 Percent of key watershed in: Late Succession Reserves*	Admin. Withdrawn Areas	Riparian Reserves	Matrix	OPTION 6 & 10** Percent of key watershed in: Late Succession Reserves	Admin Withdrawn Areas	Riparian Reserves	Matrix
Washington														
Eastern Cascades	3,472,400	46	27	8	6	12	21	12	7	14	22	10	6	17
Western Cascades	3,721,700	37	45	6	5	7	42	8	6	8	40	9	4	10
Western Lowlands	126,300	0	0	0	0	0	0	0	0	0	0	0	0	0
Olympic Peninsula	1,518,800	22	61	0	8	8	61	0	8	8	60	0	8	11
Total:	**8,839,200**	**40**	**37**	**7**	**6**	**10**	**33**	**9**	**6**	**11**	**32**	**9**	**5**	**14**
Oregon														
Klamath	2,106,200	8	66	3	10	13	59	4	13	17	61	4	10	17
Eastern Cascades	1,557,400	23	49	4	9	15	25	17	12	23	44	4	7	21
Western Cascades	4,478,200	23	39	2	16	20	23	4	22	28	37	3	12	26
Coast Range	1,396,800	6	80	0	7	7	80	0	7	7	75	0	7	12
Willamette Valley	25,600	0	0	0	56	56	0	0	56	56	0	0	28	56
Total:	**9,564,200**	**17**	**52**	**2**	**13**	**16**	**40**	**5**	**17**	**22**	**48**	**3**	**10**	**21**
California														
Coast Range	388,200	18	50	11	8	13	50	11	8	13	45	9	7	21
Klamath	4,459,900	41	26	9	11	13	22	10	12	15	24	11	8	17
Cascades	1,009,200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Coast Range	1,396,800	6	80	0	7	7	80	0	7	7	75	0	7	12
Willamette Valley	25,600	0	0	0	56	56	0	0	56	56	0	0	28	56
Total:	**9,564,200**	**17**	**52**	**2**	**13**	**16**	**40**	**5**	**17**	**22**	**48**	**3**	**10**	**21**
California														
Coast Range	388,200	18	50	11	8	13	50	11	8	13	45	9	7	21
Klamath	4,459,900	41	26	9	11	13	22	10	12	15	24	11	8	17
Cascades	1,009,200	0	0	0	0	0	0	0	0	0	0	0	0	0
Total:	**5,857,300**	**40**	**27**	**9**	**11**	**13**	**23**	**10**	**12**	**15**	**24**	**11**	**8**	**17**
Three-State Total:	**24,260,700**	**33**	**39**	**6**	**9**	**13**	**33**	**8**	**11**	**15**	**35**	**7**	**8**	**17**

* Includes 147,000 acres of managed late-successional areas.

** Table information is the same for Option 6 and Option 10

Table V-H-2. (Tier 1 Watersheds continued)

			OPTION 7				OPTION 8				OPTION 9				
			Percent of key watershed in:				Percent of key watershed in:				Percent of key watershed in:				
State/ Physiographic province	Total acres federal land	Congress Withdrawn Areas	Late Succession Reserves*	Admin. Withdrawn Areas	Riparian Reserves	Matrix	Late Succession Reserves	Admin. Withdrawn Areas	Riparian Reserves	Matrix	Late Succession Reserves	Managed Late-Succession Reserves	Admin Withdrawn Areas	Riparian Reserves	Matrix
Washington															
Eastern Cascades	3,472,400	46	21	12	1	20	22	10	4	19	26	2	7	7	13
Western Cascades	3,721,700	37	38	9	1	15	40	9	3	12	41	3	6	6	8
Western Lowlands	126,300	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Olympic Peninsula	1,518,800	22	50	1	2	25	60	0	6	12	66	12	0	0	0
Total:	**8,839,200**	**40**	**31**	**10**	**1**	**18**	**32**	**9**	**3**	**15**	**35**	**3**	**6**	**6**	**10**
Oregon															
Klamath	2,106,200	8	27	13	4	48	61	4	6	21	55	7	4	12	15
Eastern Cascades	1,557,400	23	25	17	2	33	44	4	5	24	46	0	4	10	17
Western Cascades	4,478,200	23	23	4	4	47	37	3	8	30	46	1	2	12	16
Coast Range	1,396,800	6	69	0	2	22	75	0	5	14	63	20	0	5	6
Willamette Valley	25,600	0	0	0	0	84	0	0	28	84	0	0	0	56	56
Total:	**9,564,200**	**17**	**31**	**7**	**3**	**42**	**48**	**3**	**6**	**25**	**50**	**5**	**2**	**11**	**15**
California															
Coast Range	388,200	18	50	11	1	20	45	9	5	23	50	0	11	8	13
Klamath	4,459,900	41	16	12	2	29	24	11	5	20	25	3	10	10	12
Cascades	1,009,200	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total:	**5,857,300**	**40**	**17**	**12**	**2**	**29**	**24**	**11**	**5**	**20**	**26**	**2**	**10**	**10**	**12**

Total:	**9,564,200**	**17**	**31**	**7**	**3**	**42**	**48**	**3**	**6**	**25**	**50**	**5**	**2**	**11**	**15**
California															
Coast Range	388,200	18	50	11	1	20	45	9	5	23	50	0	11	8	13
Klamath	4,459,900	41	16	12	2	29	24	11	5	20	25	3	10	10	12
Cascades	1,009,200	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total:	**5,857,300**	**40**	**17**	**12**	**2**	**29**	**24**	**11**	**5**	**20**	**26**	**2**	**10**	**10**	**12**
Three-State Total:	**24,260,700**	**33**	**27**	**10**	**2**	**28**	**35**	**7**	**5**	**20**	**37**	**4**	**6**	**8**	**12**

* Includes 147,800 acres of managed late-successional areas.

Table V-H-3. Percentage of Tier 2 Key Watersheds by allocation by option by state and physiographic province.

			OPTION 1 Percent of key watershed in:				OPTION 2 Percent of key watershed in:				OPTION 3 Percent of key watershed in:				
State/ Physiographic province	Total acres federal land	Congress Withdrawn Areas	Late Succession Reserves	Admin Withdrawn Areas	Riparian Reserves	Matrix	Late Succession Reserves	Admin Withdrawn Areas	Riparian Reserves	Matrix	Late Succession Reserves	Managed Late-Succession Reserves	Admin. Withdrawn Areas	Riparian Reserves	Matrix
Washington															
Eastern Cascades	3,472,400	16	51	2	16	15	48	3	13	20	48	0	3	13	20
Western Cascades	3,721,700	42	50	3	2	3	46	4	3	5	40	5	5	3	5
Western Lowlands	126,300	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Olympic Peninsula	1,518,800	0	68	1	16	15	66	1	13	19	67	0	1	13	19
Total:	**8,839,200**	31	53	**3**	7	7	**49**	**4**	**6**	**10**	**45**	**3**	**4**	6	**10**
Oregon															
Klamath	2,106,200	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eastern Cascades	1,557,400	24	43	6	12	16	41	6	9	20	41	0	6	9	20
Western Cascades	4,478,200	26	56	2	5	10	45	3	6	20	36	8	4	6	20
Coast Range	1,396,800	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Willamette Valley	25,600	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total:	**9,564,200**	25	51	**4**	**7**	**13**	43	**4**	7	20	**38**	**5**	**5**	**7**	**20**
California															
Coast Range	388,200	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Klamath	4,459,900	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cascades	1,009,200	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total:	**5,857,300**	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Three-State Total:	**24,260,700**	**27**	**52**	**3**	**7**	**10**	**45**	**4**	**7**	**16**	**41**	**5**	**5**	**7**	**16**

Cascades	1,009,200	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total:	**5,857,300**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Three-State Total:	**24,260,700**	**27**	**52**	**3**	**7**	**10**	**45**	**4**	**7**	**16**	**41**	**5**	**5**	**7**	**16**

Table V-H-3. (Tier 2 Watersheds continued)

			OPTION 4 Percent of key watershed in:				**OPTION 5** Percent of key watershed in:				**OPTION 6 & 10**** Percent of key watershed in:			
State/ Physiographic province	Total acres federal land	Congress Withdrawn Areas	Late Succession Reserves*	Admin. Withdrawn Areas	Riparian Reserves	Matrix	Late Succession Reserves*	Admin. Withdrawn Areas	Riparian Reserves	Matrix	Late Succession Reserves	Admin. Withdrawn Areas	Riparian Reserves	Matrix
Washington														
Eastern Cascades	3,472,400	16	75	0	4	4	71	1	5	7	48	3	13	20
Western Cascades	3,721,700	42	41	4	6	7	22	7	11	17	40	5	5	8
Western Lowlands	126,300	0	0	0	0	0	0	0	0	0	0	0	0	0
Olympic Peninsula	1,518,800	0	67	1	16	16	67	1	13	18	67	1	13	19
Total:	**8,839,200**	**31**	**51**	**3**	**7**	**7**	**37**	**5**	**10**	**16**	**45**	**4**	**7**	**12**
Oregon														
Klamath	2,106,200	0	0	0	0	0	0	0	0	0	0	0	0	0
Eastern Cascades	1,557,400	24	27	11	16	22	10	16	15	36	25	13	11	27
Western Cascades	4,478,200	26	39	3	10	21	33	3	8	29	36	4	8	27
Coast Range	1,396,800	0	0	0	0	0	0	0	0	0	0	0	0	0
Willamette Valley	25,600	0	0	0	0	0	0	0	0	0	0	0	0	0
Total:	**9,564,200**	**25**	**34**	**6**	**12**	**22**	**24**	**8**	**11**	**32**	**32**	**7**	**9**	**27**
California														
Coast Range	388,200	0	0	0	0	0	0	0	0	0	0	0	0	0
Klamath	4,459,900	0	0	0	0	0	0	0	0	0	0	0	0	0
Cascades	1,009,200	0	0	0	0	0	0	0	0	0	0	0	0	0
Total:	**5,857,300**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Three-State Total:	**24,260,700**	**27**	**41**	**5**	**10**	**16**	**29**	**7**	**11**	**26**	**37**	**6**	**8**	**21**

* Includes 147,000 acres of managed late-successional areas.

** Table information is the same for Option 6 and Option 10

Table V-H-3. (Tier 2 Watersheds continued)

OPTION 7	**OPTION 8**	**OPTION 9**

** Table information is the same for Option 6 and Option 10

Table V-H-3. (Tier 2 Watersheds continued)

State/ Physiographic province	Total acres federal land	Congress Withdrawn Areas	OPTION 7 Percent of key watershed in: Late Succession Reserves*	Admin Withdrawn Areas	Riparian Reserves	Matrix	OPTION 8 Percent of key watershed in: Late Succession Reserves	Admin. Withdrawn Areas	Riparian Reserves	Matrix	OPTION 9 Percent of key watershed in: Late Succession Reserves	Managed Late-Succession Reserves	Admin Withdrawn Areas	Riparian Reserves	Matrix
Washington															
Eastern Cascades	3,472,400	16	71	1	1	11	48	3	9	24	8	0	6	28	42
Western Cascades	3,721,700	42	21	8	3	26	40	5	3	10	29	17	4	2	6
Western Lowlands	126,300	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Olympic Peninsula	1,518,800	0	55	1	4	40	67	1	11	21	54	46	0	0	0
Total:	**8,839,200**	**31***	**35**	**6**	**3**	**26**	**45**	**4**	**5**	**14**	**29**	**18**	**4**	**6**	**11**
Oregon															
Klamath	2,106,200	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eastern Cascades	1,557,400	24	10	16	4	47	25	13	7	31	26	0	12	11	27
Western Cascades	4,478,200	26	33	3	2	35	36	4	4	30	27	0	4	9	33
Coast Range	1,396,800	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Willamette Valley	25,600	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total:	**9,564,200**	**25**	**24**	**8**	**3**	**40**	**32**	**7**	**5**	**30**	**27**	**0**	**7**	**10**	**30**
California															
Coast Range	388,200	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Klamath	4,459,900	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cascades	1,009,200	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total:	**5,857,300**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Three-State Total:	**24,260,700**	**27**	**28**	**7**	**3**	**35**	**37**	**6**	**5**	**24**	**28**	**7**	**6**	**9**	**23**

* Includes 147,000 acres of managed late-successional areas.

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Appendix I

Rationale for a Watershed Basis to Ecosystem Management

In its broadest sense, ecosystem management represents a philosophy of natural resource management that emphasizes sustaining ecological systems and functions while deriving socially-defined benefits. Ecosystems are influenced by both biological and physical changes, so if we are to design land use to sustain ecosystems, we must understand the effects of land-use activities on both the physical and biological environment, and we must understand how these components of the environment interact with each other. In order to employ ecosystem management, we must also develop human institutions for planning and decision-making to maximize beneficial uses, while minimizing environmental impacts.

The concepts of ecosystem management are still in their infancy, but include using science to define landscape states, interpret the intrinsic potential of landscapes to produce desired outputs, and predict the consequences of activities on ecosystems and human communities. Implementing ecosystem management on federal lands must recognize some of these emerging principles, which include:

· Multivalue: Societal expectations for forest landscapes, including beneficial uses, goods, services, economic and ecologic values must direct forest management to the extent that they do not conflict with sustaining ecosystems structure and function.

· Multiscale: The process must address issues and concerns generated at spatial scales ranging from regions, where conservation policy is formulated, to physiographic provinces, where management activities and strategies are coordinated, to smaller watersheds/landscapes where site-specific activities are planned and implemented. Strategies developed at coarser scales provides context for and guides implementation at finer scales, while information from finer scales provides feedback on assumptions and decisions made at coarser scales.

· Multiownership: Planning must include all owners in mixed ownership lands. This includes both inter-agency coordination and public participation in some type of partnership arrangement.

· Multidisciplinary: Implementing ecosystem management requires simultaneous consideration of issues traditionally viewed as independent. Wildlife viability, biodiversity, upland silviculture practices, riparian structure and function, hydrologic and geomorphic processes, among others, must be analyzed at a common spatial scale, where linkages among system elements can be evaluated, and redundancies and incompatibilities in management options be addressed.

Ecosystem planning is a multi-scale, hierarchical process designed to incorporate these principles. Central to this process is the concept that watersheds represent a physically and ecologically relevant, and socially acceptable scale for managing forest resources.

There are many reasons to consider watersheds as an appropriate spatial unit for implementing ecosystem management. They include:

Linkage across spatial scales and policy levels: Watersheds link regional conservation strategies, provincial and landscape objectives, and project implementation.

Linkage among physical processes: Many key physical processes are best understood at a watershed basis (e.g. movement of water, sediment, wood, and consequent effects on channel structure and habitat). Many of these processes are linked in time and space and tend to propagate downstream. Understanding these linkages is essential for understanding on- and off-site effects of land use.

Basis for managing key species: Some organisms are strongly tied to watersheds and associated channel networks (e.g. fish, riparian obligates); others that are not (e.g. owls) can be accounted for by including trans-watershed habitat and migration areas. Recognizing watersheds is essential to achieve objectives for organisms whose habitat needs cross ownership boundaries or that use different habitats over their life cycle (e.g. fish). Building watersheds into conservation schemes for species that are not watershed-based allows coordination and flexibility in developing management options that influence all species and may offer opportunities for creative solutions that meet multiple objectives.

Basis for addressing beneficial uses: Watersheds represent real, unchanging, physical boundaries for managing many beneficial uses of forested lands (e.g., municipal water supply, water quality, hydroelectric power, sport fisheries, irrigation). Other uses, such as recreation or timber supply to local communities are less tightly defined by watershed boundaries but watersheds can be aggregated to address these concerns. Watershed based management would allow both management and regulatory agencies to coordinate planning and implementation across multiple ownerships, and efficiently deal with complex and interconnected natural resource problems.

Basis for community involvement in natural resource planning: Watersheds provide a rational and effective spatial scale for citizens to participate in natural resource decision-making. Many,of the best examples of community-based resource planning -- the Applegate.Project in southern Oregon and the Mattole and Redwood Community Watershed Associations in northern California -- are organized on a watershed basis. Watersheds represent a natural demarcation of geography that encompasses a wide diversity of ownerships, issues, and viewpoints. They have intrinsic appeal for aesthetic, cultural, and historical reasons as well. Furthermore, a watershed basis for planning insures that those communities and individuals most directly affected by decisions have a role in decision making.

Implementing ecosystem management requires matching objectives to the intrinsic capabilities and capacities of landscapes, which requires information on geomorphic, ecologic, and social conditions and processes operating in specific landscapes. *Watershed analysis* is a systematic procedure for characterizing watershed and ecological processes to meet specific management and social objectives. It has been adopted as the basis for a number of recent planning efforts and appears to be the emerging standard for resolving environmental conflicts in the western United States. In this section, we consider how watershed analysis might contribute to ecosystem planning on federal lands.

Scales of Analysis in Ecosystem Planning

Ecosystem planning needs to be conducted at four spatial scales:-re~ional, province/river- - basin, watershed and site (fig. V-I-i). The region is defined for the purposes of this report as the Pacific Northwest, which encompasses the entire range of the northern spotted owl. River basins are areas of similar beneficial use or have particular suites of down stream resource concerns. The Klamath, Umpqua, Willamette Rivers and provincial groupings of small coastal watersheds, with common geology, climate and physiography are examples (figs. V-I-2 and V-I-3). Watersheds are sub-basins of 20-200 square miles (fig. V-I-4), and are the scale at which watershed analyses are conducted. Sites are areas of variable size but typically ranging from tens to hundreds of acres, where specific activities, such as timber harvest, watershed restoration, silvicultural treatments, or road construction take place.

At each scale, analyses describe human needs, environmental values, and important watershed and ecosystem functions. Information collected at broader spatial scales guides analysis and development of management options at finer scales. Conversely, information collected at the finer scales provides early warning of likely future problems at the broader scales. By this approach, key issues are dealt with at their appropriate spatial scales.

Interdisciplinary teams will be convened at regional, river basin, and individual watershed levels. The membership of these teams must draw from the best expertise available in public and private institutions. Analyses of each scale will be an interagency effort, drawing on personnel in a variety of agencies, including the Forest Service, Environmental Protection Agency, Bureau of Land Management, National Marine Fisheries Service, and Fish and Wildlife.

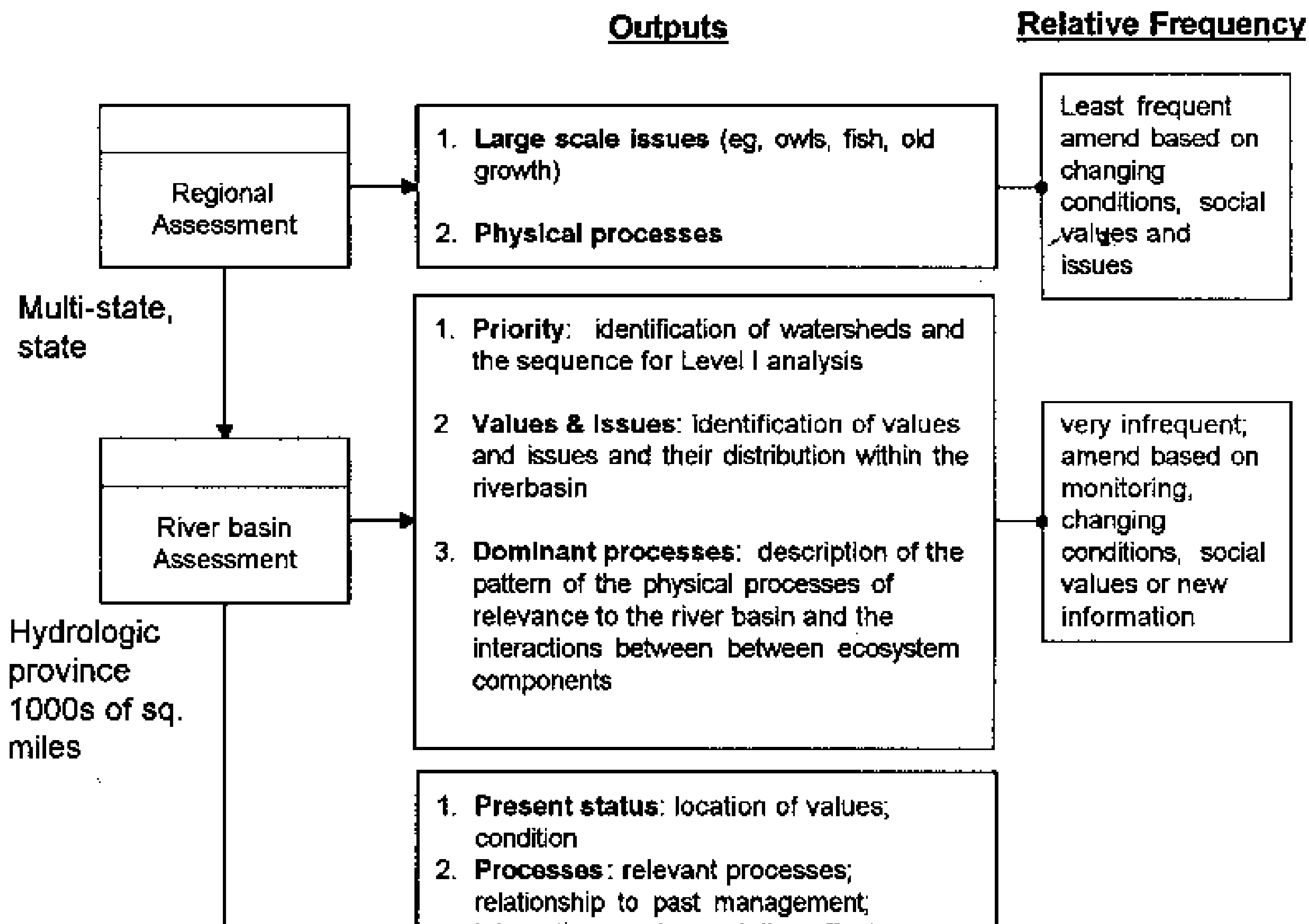
Information from the regional scale identifies important beneficial uses, resource values, and economic issues and is used to evaluate how resources in a particular river basin or watershed influeXice resource values throughout the region. In many cases, regional issues transcend river-basin or watershed boundaries and may constrain management options at these scales. For example, habitat protection for threatened and endangered species may be established as a regional network, based on region-wide habitat conditions or availability of refugia.

Regional scale issues are those that apply across thousands of square miles, and include:

1. Land allocation decisions, e.g. identified reserve systems for species conservation or old-growth forest protection.

2. Standards and guidelines to achieve regional management objectives, e.g. the 50-11- 40 rule for management of Matrix lands or riparian standards and guides.

3. Regional programs to support at-risk communities, which may include sustainable levels of commodity outputs.



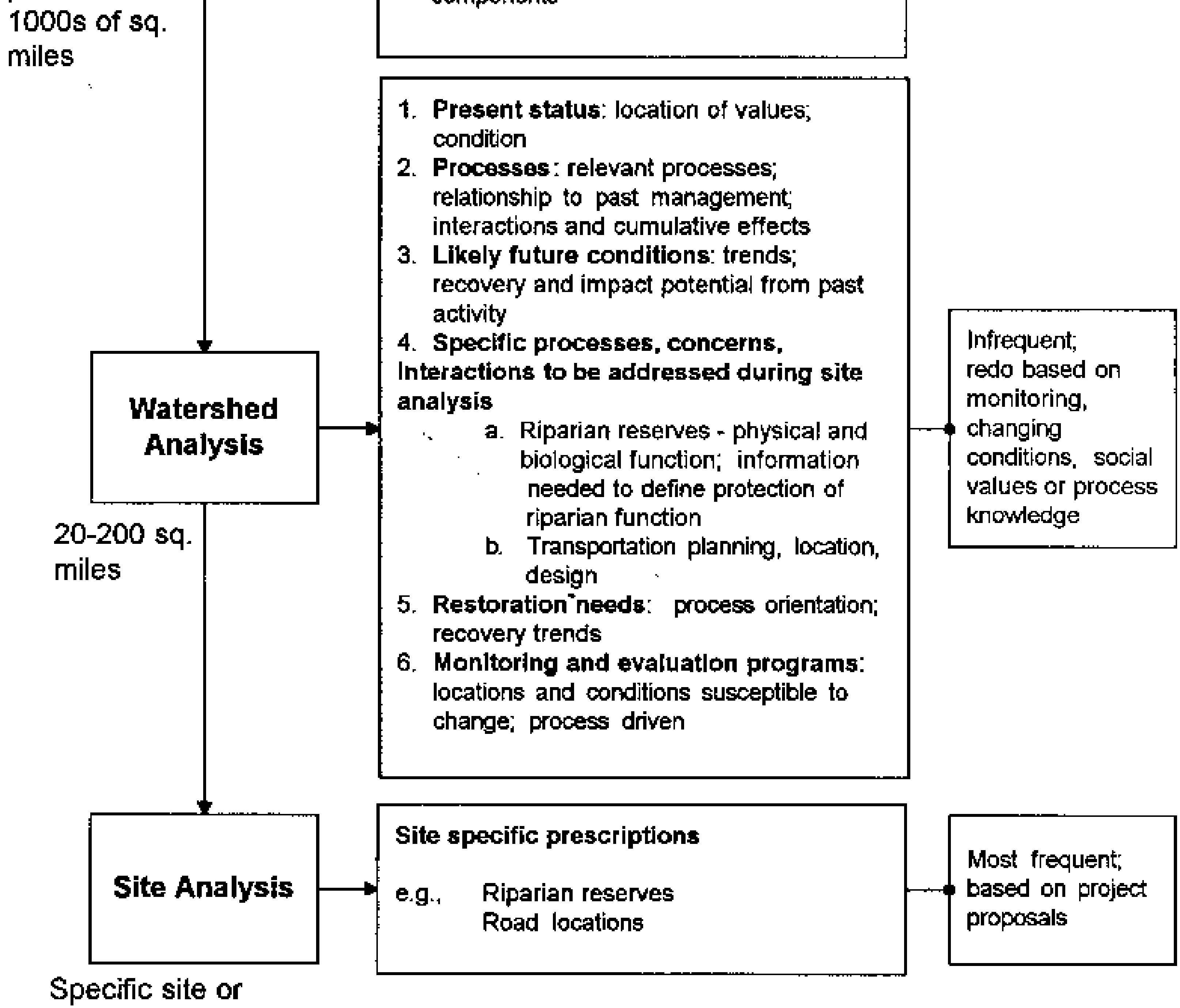
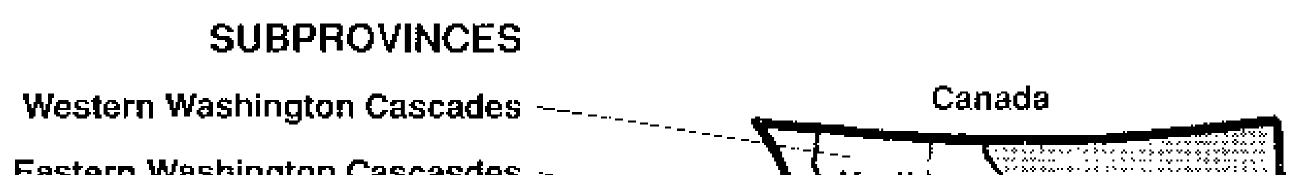
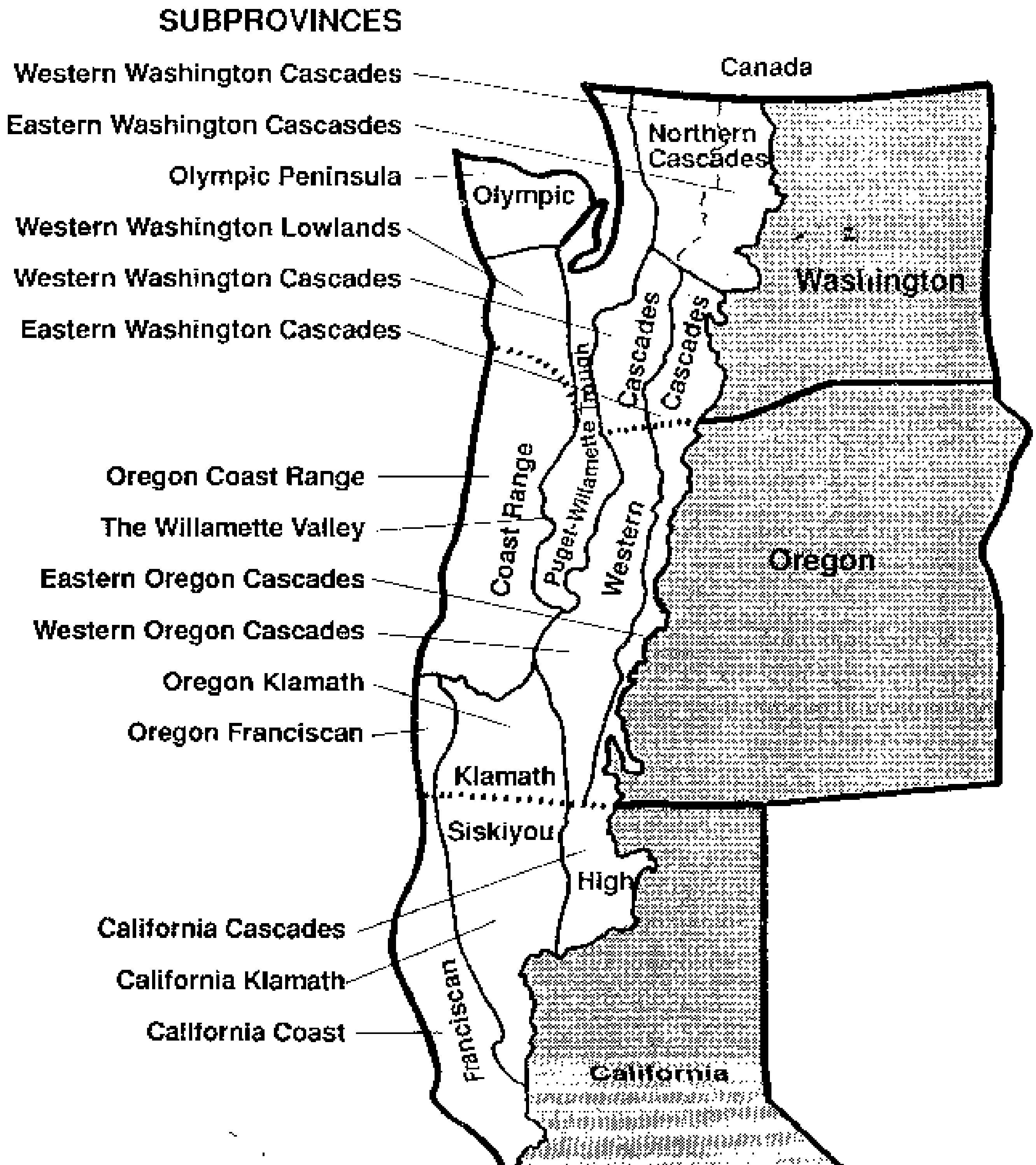


Figure V-I-1. Context for Watershed Analysis.



Specific site or
area

Figure V-I-1. Context for Watershed Analysis.



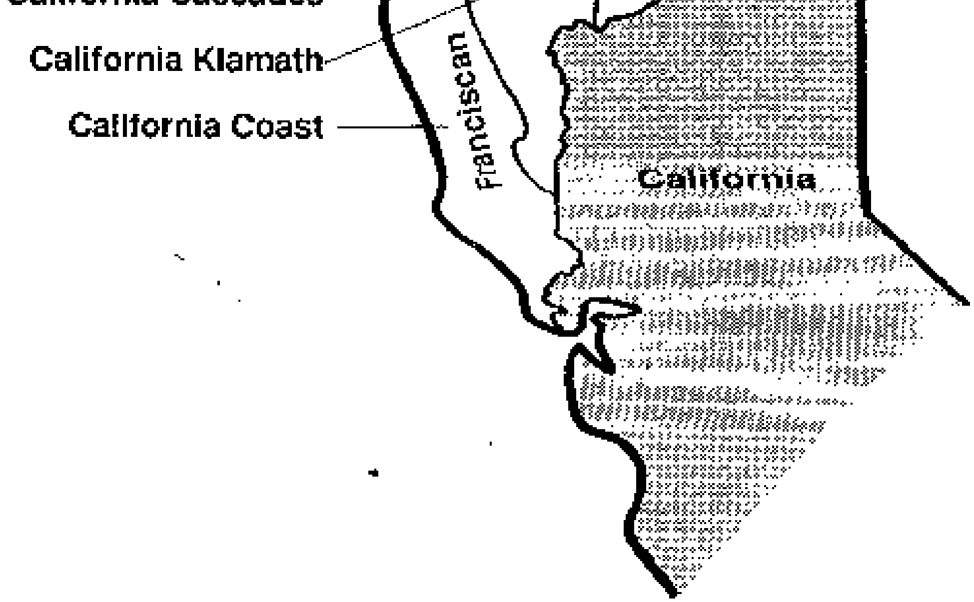
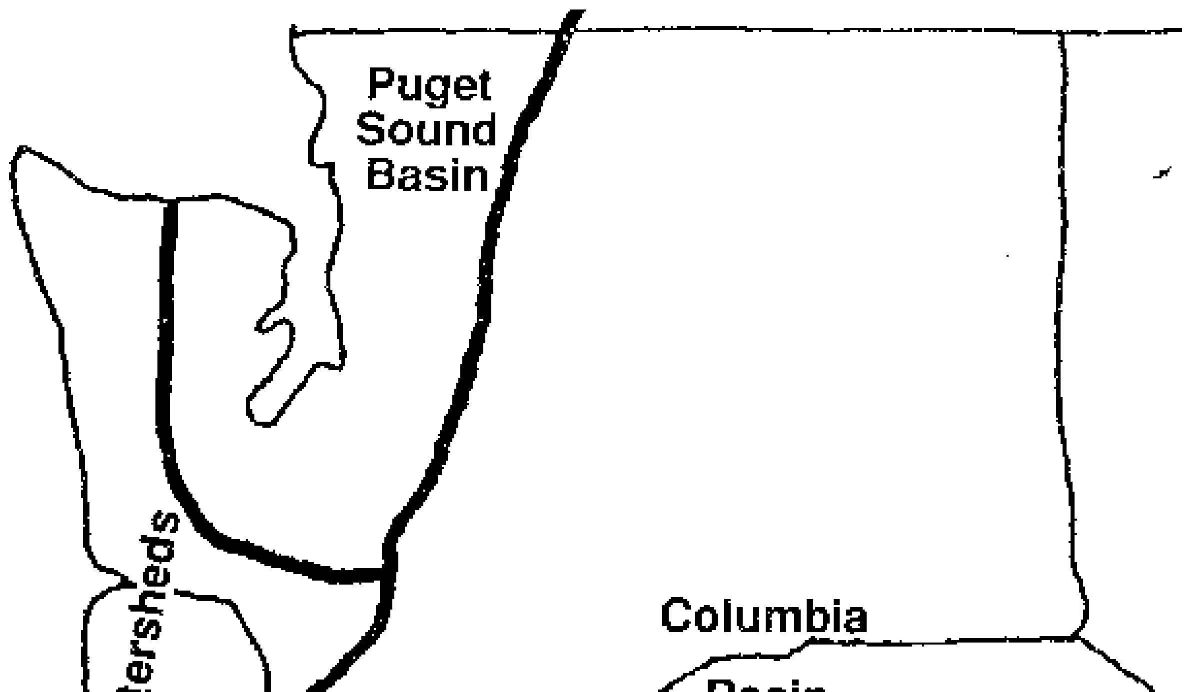
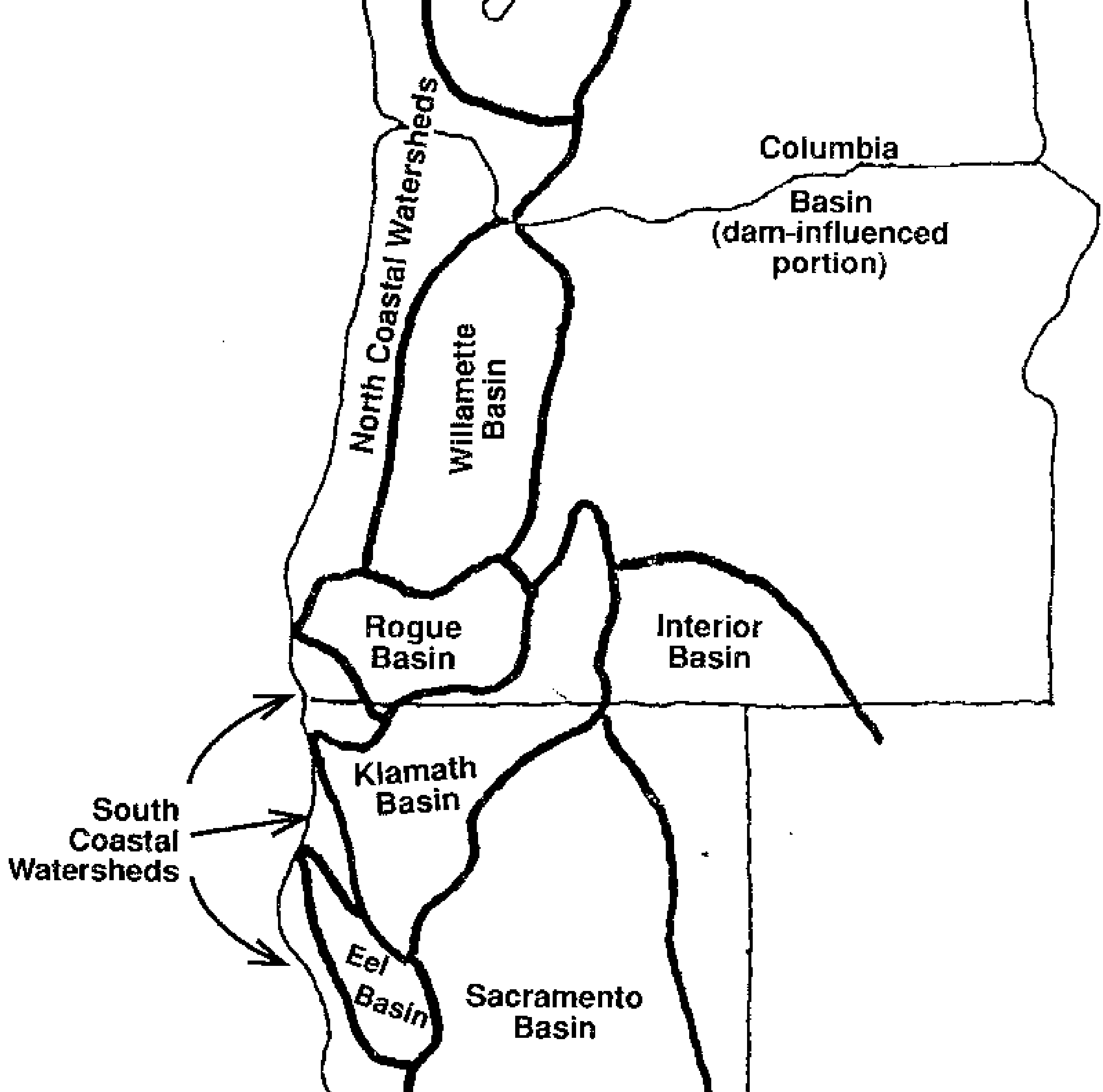


Figure V-I-2. Provinces and subprovinces.




Columbia
Basin
(dam-influenced
portion)
North Coastal Watersheds
Willamette
Basin
Rogue
Basin
Interior
Basin
Klamath
Basin
South
Coastal
Watersheds
Eel
Basin
Sacramento
Basin

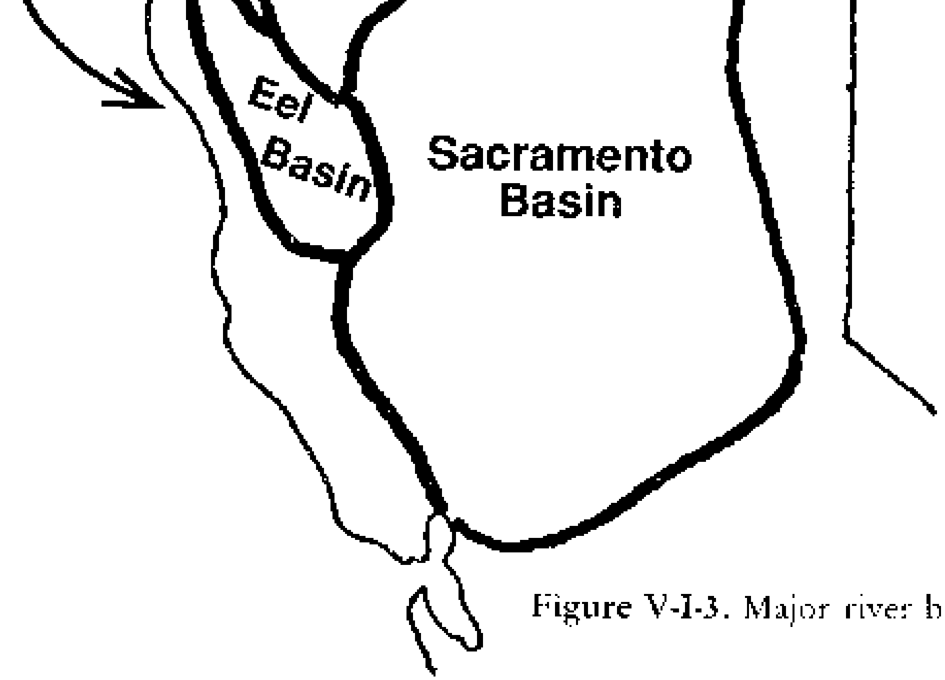
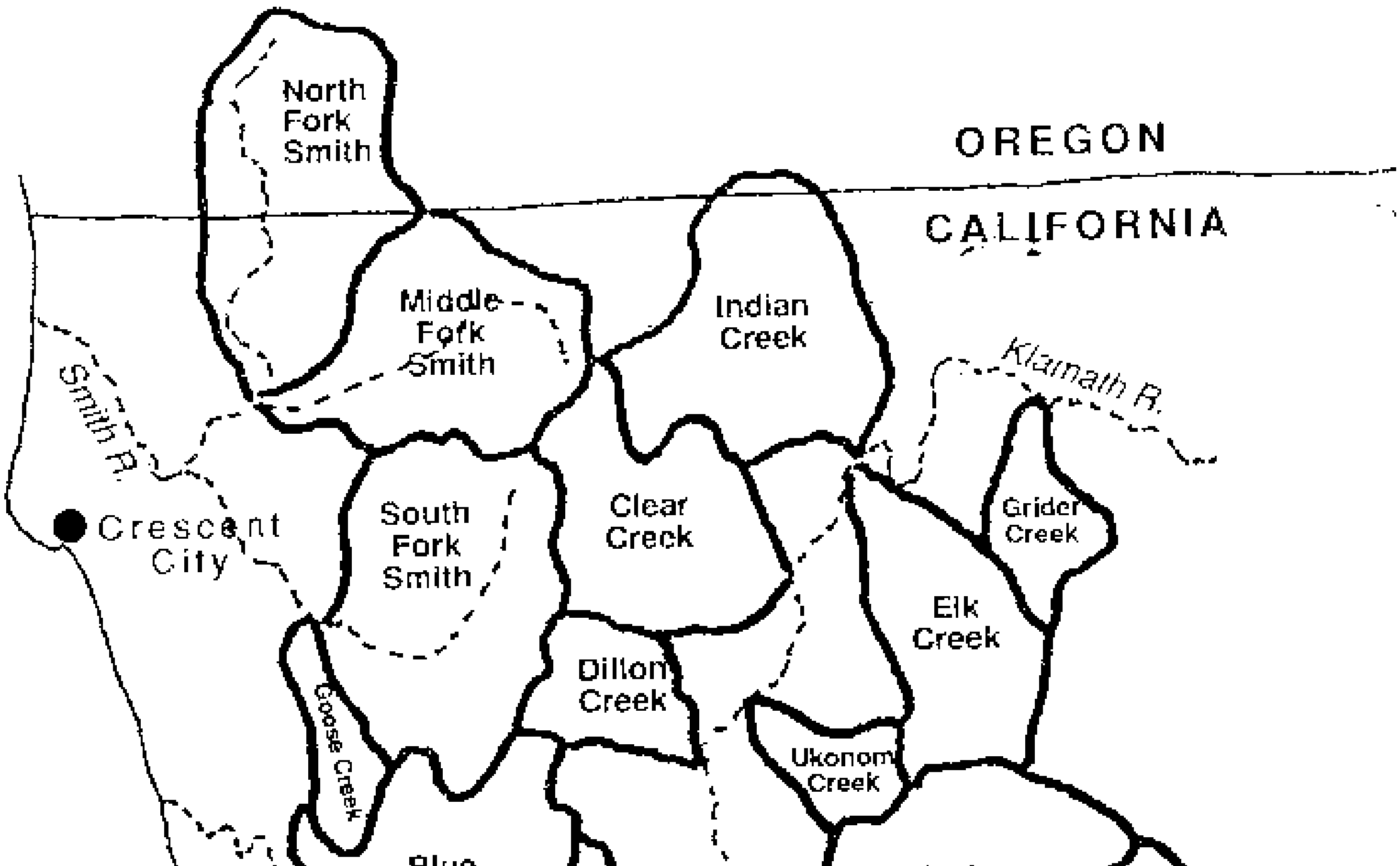


Figure V-I-3. Major river basins.



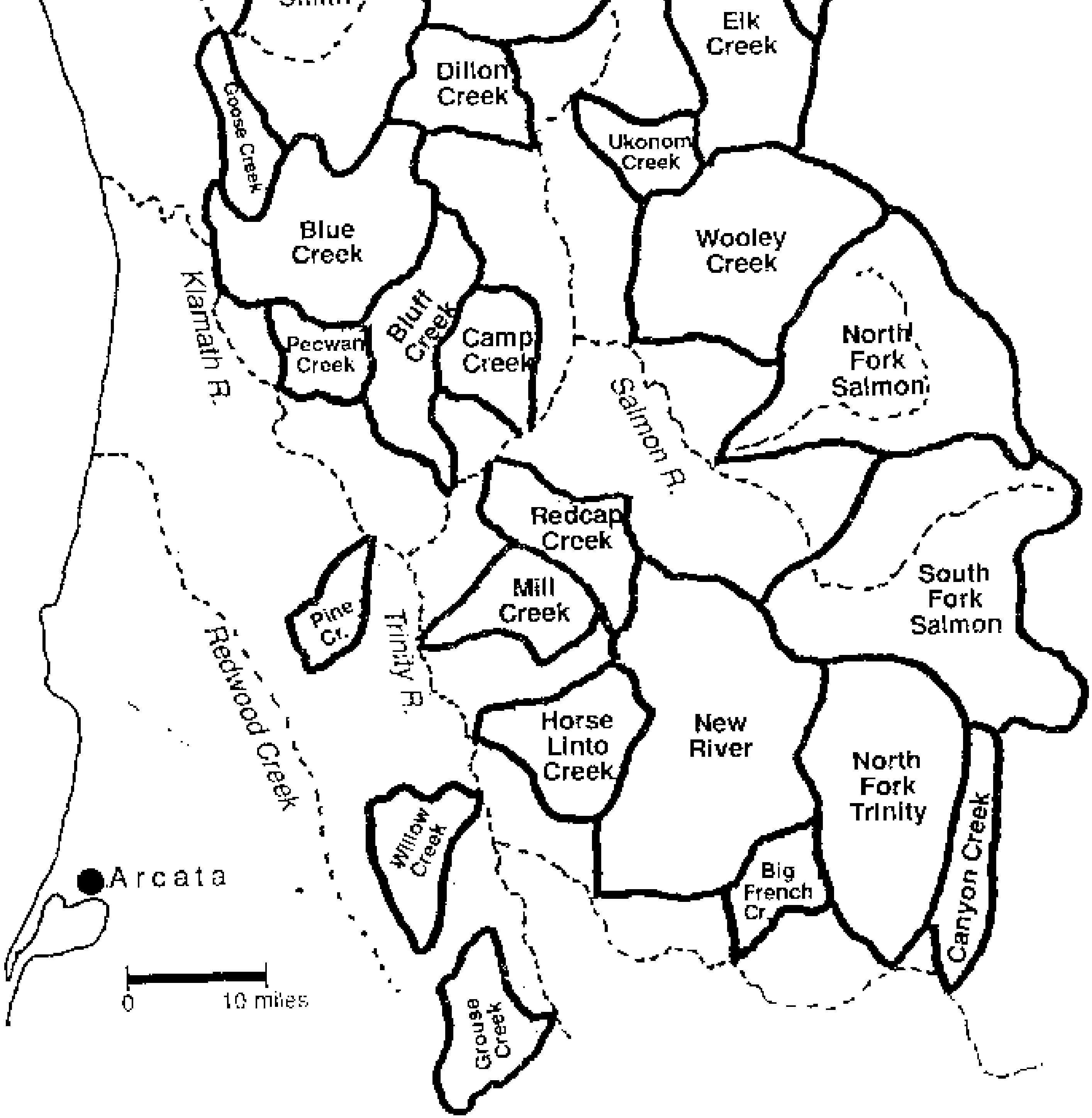


Figure V-I-4. Example of project watersheds in

Figure V-I-4. Example of project watersheds in northwest California

At the river basin scale, beneficial uses and ecosystem values for large river basins or physiographic provinces are analyzed. Physical and biological processes that affect those uses and values are identified. Goals of this phase of analysis are to:

1. Identify key resource issues and concerns, for example threatened and endangered species, historic and contemporary resource use, water quality issues, distribution of stocks or communities at risk; identify individuals and groups who can speak for these interests.

2. Identify the context of the river basin with respect to other large basins (intra-basin/regional issues that cross drainage basin boundaries)

3. Identify ownership patterns, agency boundaries and areas of jurisdiction, wilderness, and other special management areas, historical land use patterns.

4. Describe the physiographic province(s)in which the basin lies and identify key physical processes and their spatial distribution at this coarse scale, for example, parts of drainage basin subject to different types of mass movements, rain-on-snow processes etc.

5. Identify overriding ecological issues and areas, for example Key Watersheds, ecological reserves, species distributions.

6. Prioritize watersheds for analysis.

7. Integrate results from individual watershed analyses and evaluate cumulative effects at the province and river basin scales.

8. Provide a general description of physical and biological conditions within the river basin

The results of this analysis will define a minimum set of issues and maps that will guide the more detailed individual watershed analyses.

The most comprehensive analyses are conducted at the watershed scale, discussed below. Assessments of physical and biological processes, conditions, and resources are used to evaluate environmental impacts as well as management opportunities and constraints. Watersheds to be analyzed will be identified from maps developed from regional and river-basin analysis and will be approxiffiately 20-200 square miles in size. Information from watershed analysis is used to design management alternatives to meet objectives that are compatible with watershed and ecosystem function, and to guide site-level planning, the fourth scale of analysis. The preferred alternative identified in the Draft EIS, Elk River, Wild and Scenic River Management Plan is an example of how information obtained through watershed analysis might be used to develop management allocations (fig. V-I-5). Monitoring activities can be planned and initiated at this level.

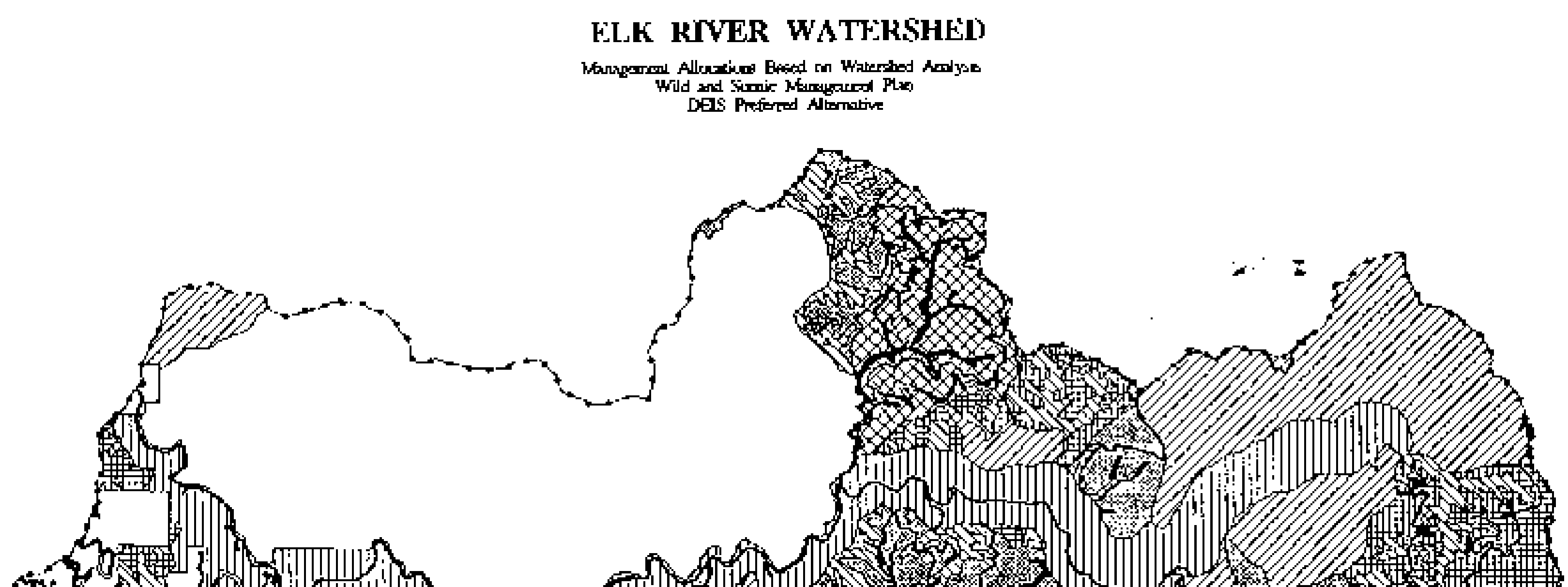
Finally, at the site-scale of tens to hundreds of acres, individual projects are planned and initiated. These may include timber sales, silvicultural treatments, restoration activities, and so on, and are designed to be compatible with information developed in the watershed-level analyses. Monitoring activities are also planned and initiated at this scale.

In addition to these four spatial scales, ecosystem planning must also consider several temporal scales. Assessments of beneficial uses, values, and impacts must incorporate
longer time periods than those usually addressed in the past. At each spatial scale, analysis must:

· Encompass the full range of past impacts;

· Encompass the full range of likely future impacts, including best-guess estimates for mixed-ownership lands;

· Consider time periods long enough to represent rare natural catastrophes such as major floods, fires, windstorms, and droughts (e.g., 100 years). The analysis should also consider the possible effect of potential, but unmeasurable concerns such as global climate change.



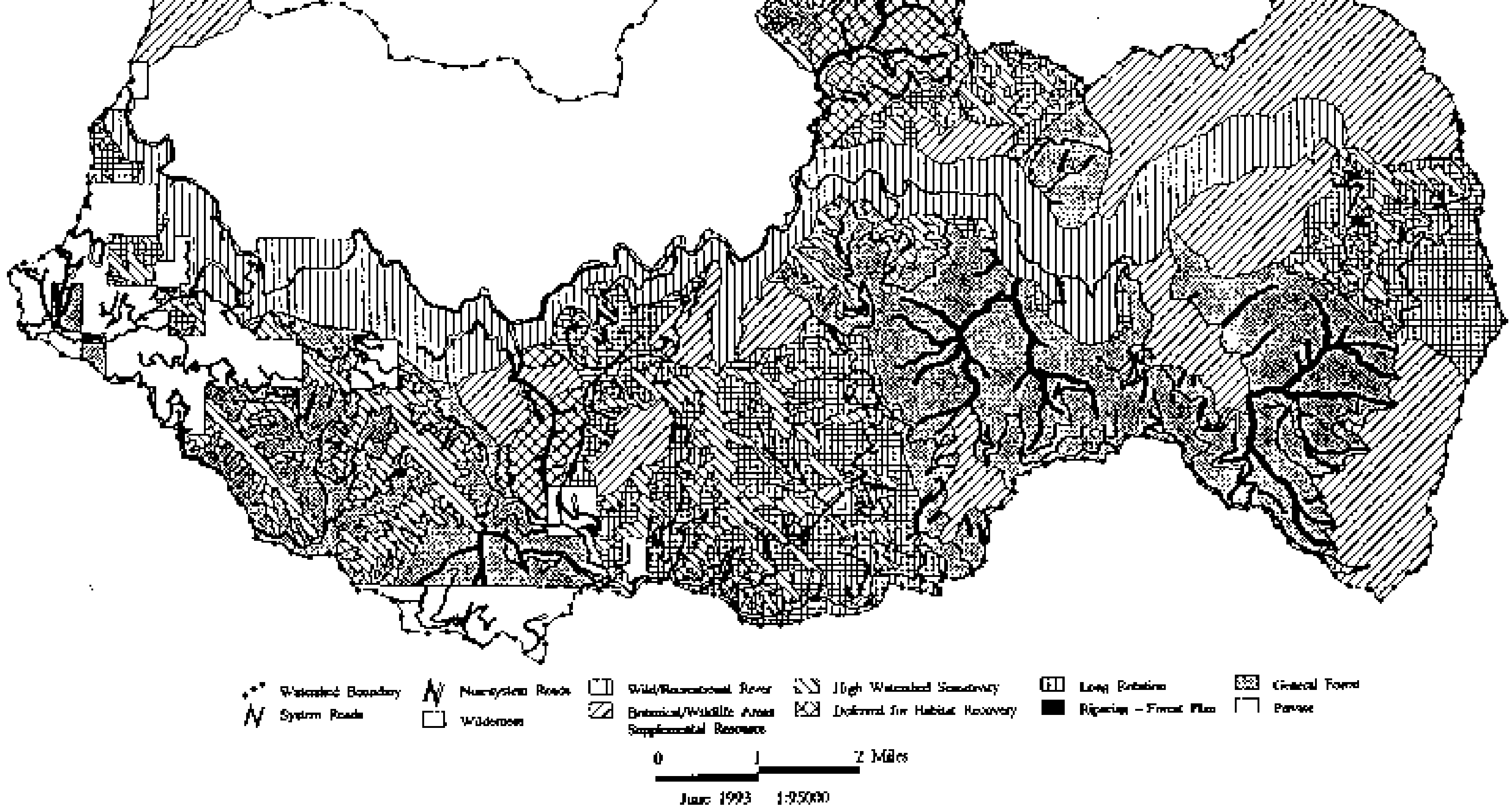


Figure V-I-5. Elk River watershed: management allocations based on watershed analysis.

Analytical Framework for Watershed Analysis

Watershed analysis develops and integrates information on physical and biological processes and conditions. It also analyzes social values, uses, and perceptions as they apply to a specific landscape. Development of information in each of these areas is guided by a set of analysis modules that describe key processes and components of watershed and ecosystem function as well as human/social values for watershed products, attributes, and amenities. While these modules can be defined independently, considerable overlap exists among modules. A key component of watershed analysis is the opportunity to explore areas of overlap, for example between upland terrestrial ecology and riparian issues or the relation between ecological process and societal expectations for the watershed. Because of their comprehensive nature, watershed analyses are carried out by interdisciplinary teams.

The goals of watershed analysis are:

1. Determine the type, areal extent, frequency, and intensity of watershed processes, including mass movements, fire, peak and low streamflows, surface erosion, and other processes affecting the flow of water, sediment, organic material, or disturbance through a watershed.

2. Using the results from #1, interpret the natural disturbance regime of both riparian zones and uplands and compare with disturbance regime under managed conditions.

3. Identify parts of the landscape, including hillslopes and channels, that are either sensitive to specific disturbance processes or critical to beneficial uses, key stocks or species.

4. Determine the distribution, abundance, life histories, habitat requirements, and limiting factors of critical species identified by the regional or river basin analyses, e.g. fish, owls, other riparian dependent species.

5. Identify beneficial uses, societal concerns and issues, and public perceptions and uses of the watershed.

6. Integrate the information generated to describe physical and biological conditions and into a set of management options, opportunities, and constraints.

7. Establish ecologically and geomorphically appropriate criteria for establishing boundaries of Riparian Habitat Conservation Areas and other special protection areas.

8. Design approaches to evaluate and monitor the reliability of the analysis procedure and the effectiveness of adopted management activities.

9. Identify restoration objectives, strategies and priorities.

Several elements of the proposed procedure allow watershed analysis io be can ied out efficiently and relatively rapidly. First, most of the required inform~ion already exists (topographic maps, aerial photographs, climatic records, geologic maps, soils maps. land- use history, and resource information). Second, issues that are relevant to a particular management activity or downstream resource can be focused on from the start. This approach allows the nature and precision of the information required to be defined beforehand, and thus avoids collection of information that will have little utility in the analysis. Third, watersheds and areas within watersheds can be stratified according to their susceptibility to disturbance. Representative sites within each stratum can then be evaluated and the results used to characterize responses throughout the stratum. This strategy allows large areas to be assessed quickly.

<u>Watershed analysis</u> is carried out by a Watershed Interdisciplinary Team made up of four to six specialists acquainted with the area. Members of this interagency team have training equivalent to that of Forest Service District specialists (Bachelor's degree with several years' experience), augmented by a training session in watershed analysis. Disciplines represented on the team vary between watersheds, but a team is likely to include a forester/botanist, geomorphologist/geologist/hydrolOgist, aquatic ecologist'fish biologist, terrestrial ecologist/wildlife biologist. In particular, the geologist or hydrologist must have training in geomorphology. A handbook, described at the end of this section, is beinu developed that describes techniques and procedures used for watershed analysis.

<u>Application of information from watershed analysis</u>: Watershed analysis reports will organize the information generated into a framework useable by decisionmakers. Reports might include descriptions of:

1. Management strategies to optimize ecologic protection by jointly considering upland and riparian zone functions, for example by extending upland reserves into riparian zones, or by designing riparian zone buffers to meet upland objectives.

2. Management strategies to model land use activities on vegetation patterns interpreted as resulting from natural disturbance regimes (e.g. fire, windthrow, debris flow). This might influence the structure and areal extent of protection areas.

3. Using results from on~ module to predict effects on resources analyzed under a different module. For example, evaluations of the distribution of seasonally satorated areas might also be used to predict distribution of upland amphibians or other organisms requiring moist habitat.

4. Creative approaches to addressing apparent social conflicts. For example. concerns about visual impacts from timber harvest could be modelled for the watershed and included in timber sale layout and design.

5. Optimizing design of transportation network to jointly meet riparian, upland silviculture, water quality, and recreation objectives.

6. Directly addressing legal requirements posed by National Environmental Policy Act, Environmental Policy Act, National Forest Management Act, Endangered Species Act to consider viability issues, or cumulative effects.

7. Strategies for development of restoration or monitoring programs.

Watershed analyses provide general guidelines and constraints on specific management activities. Site-specific analyses allow development of implementation plans for management activities consistent with management opportunities and constraints identified by the watershed analyses.

Restoration: The goal of watershed restoration is to restore desired conditions and processes. Restoration opportunities and constraints must be evaluated in the context of watershed processes if restoration strategies are to be effective. Watershed analysis provides the foundation upon which to build efficient, effective restoration programs. Without the benefit of watershed analysis, restoration efforts may be largely ineffective. See appendix J for a detailed discussion of restoration.

Monitoring: Monitoring provides the feedback that guides management adaptation. At the narrowest scale of monitoring, the specific management activities prescribed by watershed analysis will be evaluated to determine: (I) if practices are actually implemented as prescribed, and (2) if the prescribed practices are effective. Which attributes are useful to measure depends on the processes active in a watershed and the types of impacts of concern. Consequently, monitoring projects must be guided by the results of watershed analysis.

Monitoring also increases knowledge of watershed processes, cumulative effects, conditions, and trends through time. Watershed analyses are likely to reveal gaps in basic knowledge. For example, predictive models may need to be calibrated for a particular watershed. Thus, monitoring will provide additional information about processes and linkages that are poorly understood.

Research: An active research program is a necessary component of long-term ecosystem planning that incorporates watershed analysis. Watershed analysis requires understanding the linkages between management activities, geomorphic processes, habitat structure and dynamics, and ecosystem response. In reality, our knowledge of these linkages is limited. Obviously, management decisions cannot be forestalled until these linkages are completely understood. Rather~ watershed management needs to be based on the best available knowledge. Given the inherent complexity of watershed and ecological processes, and the consequent uncertainty of our knowledge, it is extremely important that our understanding of ecological and geomorphic processes improve through long-term research. Watershed analysis methods must be regularly updated to incorporate this increased understanding.

A handbook is currently being prepared that describes the strategy to be used for watershed analysis on federal lands in the western United States. The handbook will also provide outlines of analytical techniques that may be used. However, the handbook is not intended to be used as a cookbook: it assumes a high level of expertise within each of the disciplines represented on the watershed analysis team. Any analysis problem can be approached using a variety of methods, and professionals on the analysis team are in the best position to decide which methods are most appropriate in a particular area.

atershed analysis on the scale envisioned involves some difficult problems. Results must be produced quickly, yet the issues, ecosystems, and watershed processes to be evaluated are extremely complicated. The analysis strategy is thus designed to simplify the analysis as much as possible. This is feasible for several reasons:

1. A preliminary diagnosis of issues, impacts, and watershed processes can be used to closely focus the types of analyses required during a watershed analysis.

2. Many land-use decisions can be based on a qualitative description of the distribution and types of conditions in a watershed. Rarely are precise measurements of process rates necessary.

3. Watersheds can be stratified into areas that behave uniformly with respect to particular processes. Thus, understanding obtained from site-specific measurements may logically be extrapolated to other areas within the same strata.

This strategy is presented in the form of a sequence of tasks in the handbook.

Task 1 is the compilation of the background information available for the watershed. This task will be carried out over a two-month period before the analysis actually begins by the agencies responsible for land management in the watershed. The handbook describes minimum data needs and sources to canvas for other useful data. Quick methods for filling in data gaps are also described.

Task 2 uses interviews with local experts and concerned people to provide preliminary information about the issues, impacts, and locations of primary concern in the watershed.

Task 3 provides a preliminary diagnosis of the types of ecosystem and watershed conditions that will need to be evaluated in more detail. Likely impact mechanisms are identified for each issue using existing information. Methods for diagnosis are described by the handbook. Slope stability analysis for Augusta Creek is an example in which likely impact mechanisms are identified (fig. V-I-6). Distribution of areas subject to slope instability was interpreted from information contained within the Willamette National Forest Soil Resource Inventory. Slope data for each mapped unit was extracted from the Willamette National Forest Soil Resource Inventory based on whether hillslope gradients were less than 30 degrees, between 30 and 60 degrees, and greater than 60 degrees. Geologic descriptions from the Willamette National Forest Soil Resource Inventory were used to determine whether underlying bedrock was hard, moderately hard, or soft. A rating Matrix combining these two variables was used to assign a hazard rating of low, moderate, or high slide potential to each mapped unit (fig. V-J-6). Predicted hazard ratings.were tested and found to be in excellent agreement with the historical pattern of landslides observed on aerial photographs. This step ensures that field and analysis time will be used efficiently to address the most important processes and issues in the watershed.

Task 4 uses results of Task 3 to stratify the watershed into subareas that can be evaluated as uniform response units for each of the processes or issues of concern. The process of determining debris flow susceptibility for Augusta Creek is an example of how a watershed might be stratified and how this stratification may be used as a basis mapping of Riparian Reserves (fig. V-I-ic). To determine the susceptibility of different stream reaches to debris flows, a stream network map was overlaid on the slide potential map (fig. V-I-6). Areas with high slope instability were assumed to be most likely to generate debris flows. First-order channels (headward channels without tributaries) were assigned a debris flow hazard rating equal to the slide potential of the surrounding landscape (fig. V-I-6). Debris flow hazard to higher order channels downstream was assumed to he a function of two factors: channel gradient (fig. V-I-7) and tributary by B junction angle (fig. V-I-8), based on work enda (1985) and others. Debris flow hazard was reduced on class where channel gradient was less than three degrees or tributary junction angle exceeded 70 degrees, to produce a map of debris flow potential (fig. V-I-9). The stratification will vary according to process or issue. The handbook describes methods for stratification, and outlines parameters that may be useful for different types of stratification.

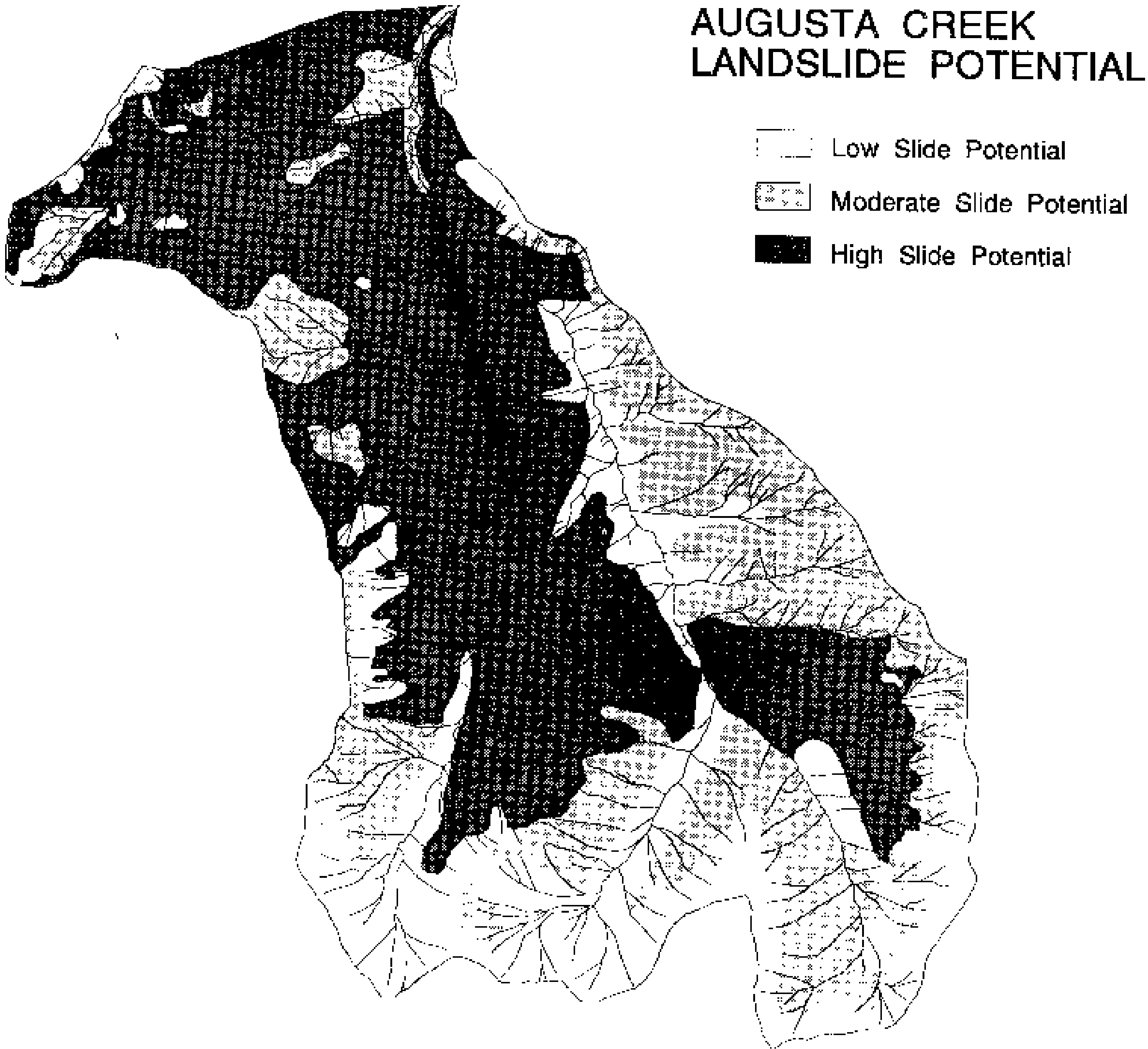

AUGUSTA CREEK
LANDSLIDE POTENTIAL
Low Slide Potential
Moderate Slide Potential
High Slide Potential

Figure V-I-6. Landslide potential with stream network, Augusta Creek basin, Willamette National Forest.

Task 5 identifies existing impacts and altered conditions, their locations, and their immediate causes. This step is primarily field based, md methods that have been found useful for these types of analysis are described by the handbook.

Task 6 describes the pathways of influence between land-use activitIes rind environmental changes. This task is an extension of the fieldwork and analysis of Task 5. The handbook describes the types of information necessary for determining impact causes and for determining the sensitivity of sites and biological communities to change.

Task 7 evaluates the type and location of impacts to be expected in the future due to existing land use. Many changes will not occur until triggered by large storms, or tintil existing changes are transported downstream to sensitive sites. iTie handbook describes methods for predicting these future changes.

The handbook presents analytical methods as modules that can easily be revised or replaced as new techniques are validated.

The handbook also outlines the format and content of the Watershed Armlvsis Report. The first section of the reports will describe conditions and impact mechanisms in the watershed, including:

1. A description of existing conditions in the watershed, including the distribution of important resources, values, and species; and the distribution and severity of environmental changes.

2. A description of impact mechanisms in the watershed and their association with land-use activities.

3. A description of future environmental changes that may occur because of the present distribution of land use.

The second section will specify the watershed processes and ecosystem concerns and interactions that will need.to be addressed at a project-planning scale in different parts of the watershed. Specific applications will he described for:

1. Delineation of Riparian Reserves.

2. Restoration planning.

3. Monitoring.

4. Transportation planning.

5. Cumulative effects assessments.

6. General land-use planning.

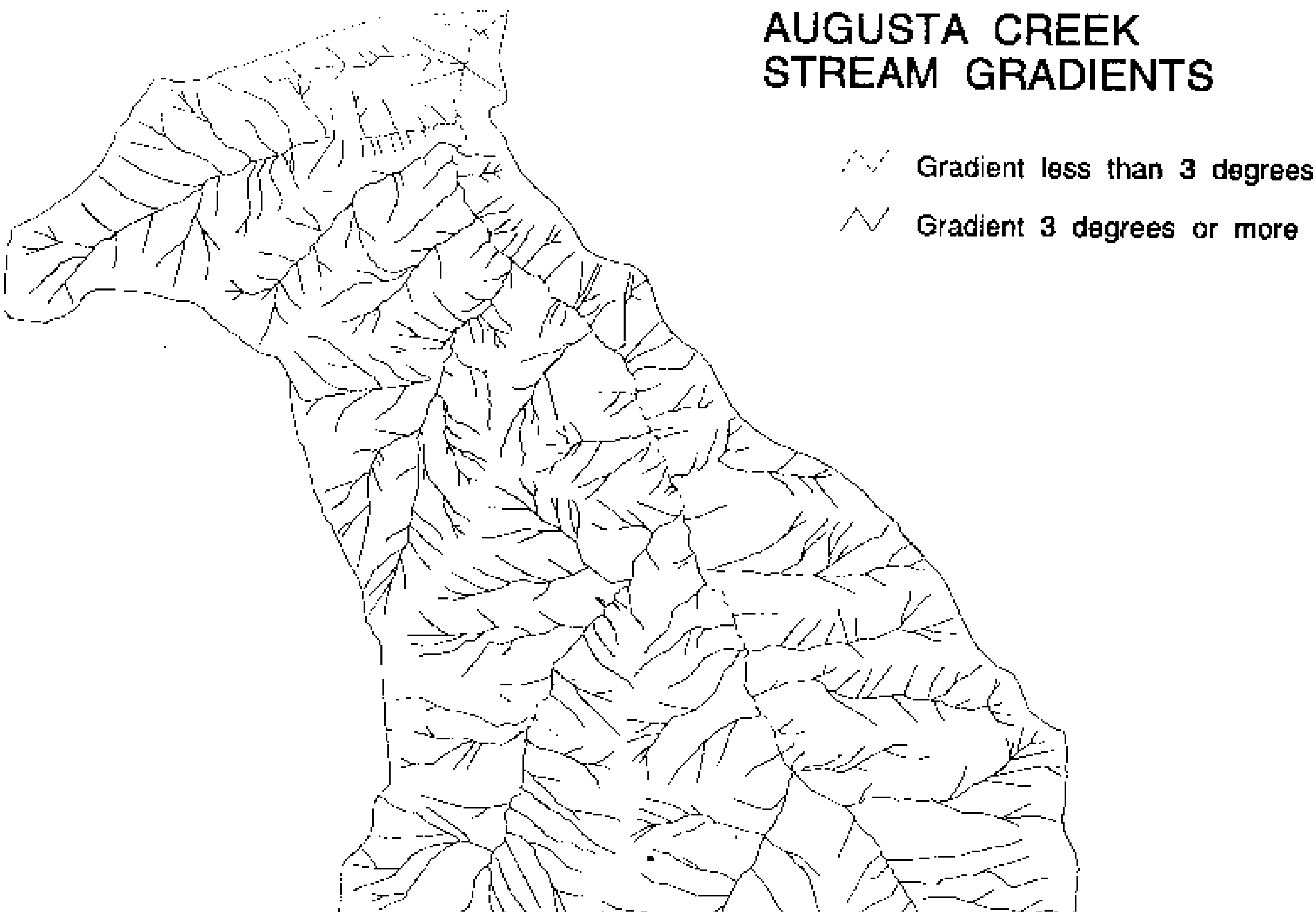
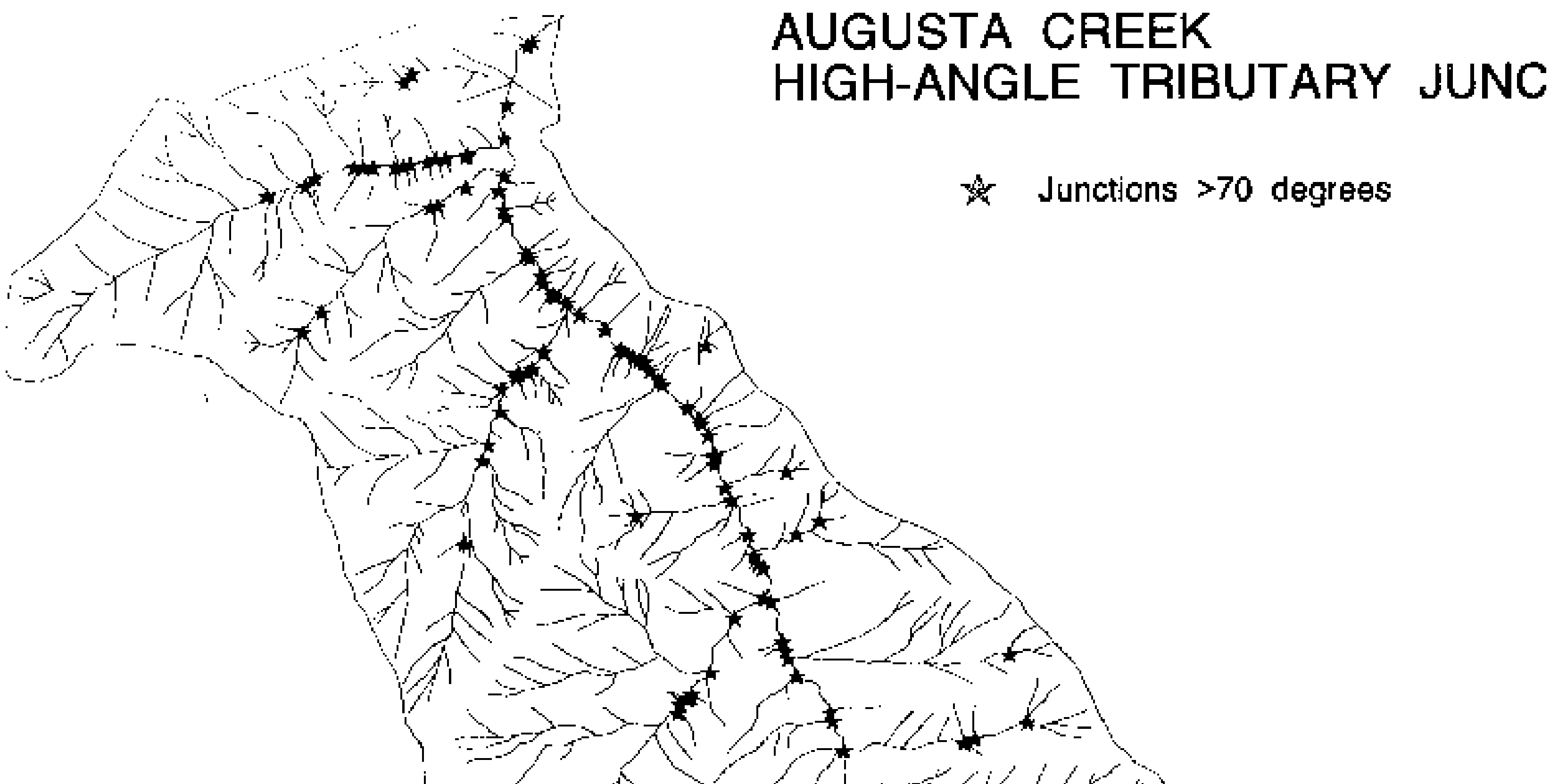


Figure V-I-7. Distribution of stream reaches with channel gradients greater than and less than 3 degrees, Augusta Creek basin, Willamette National Forest.



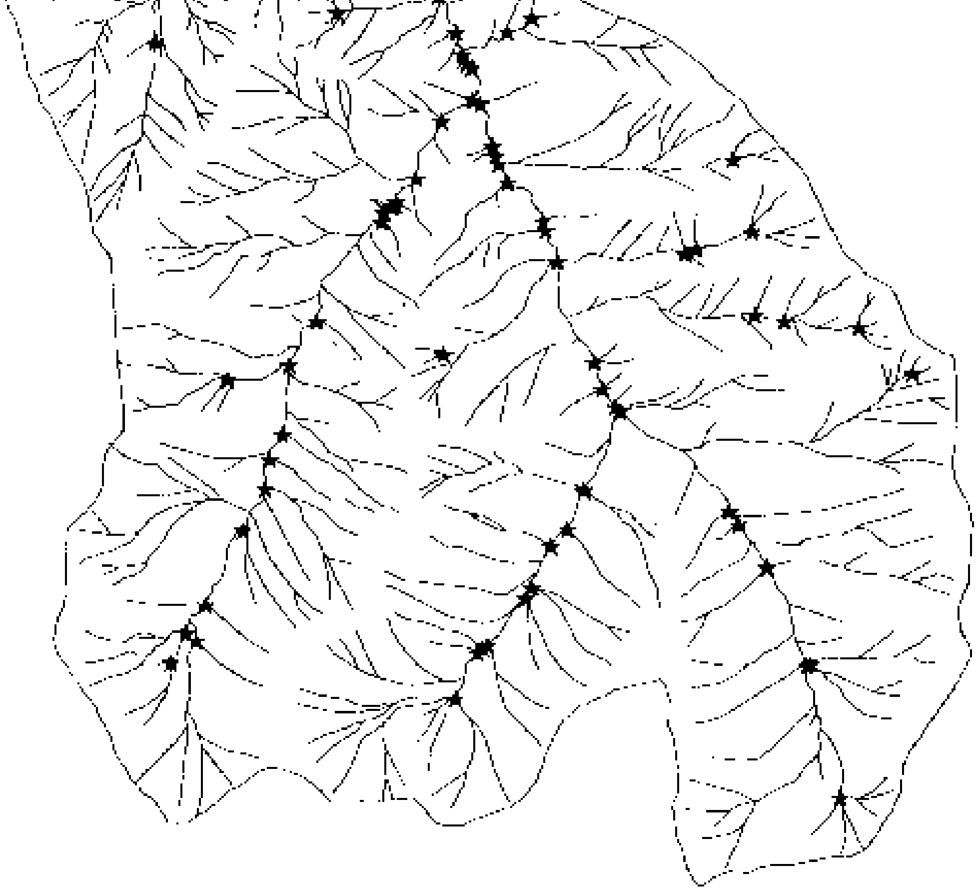
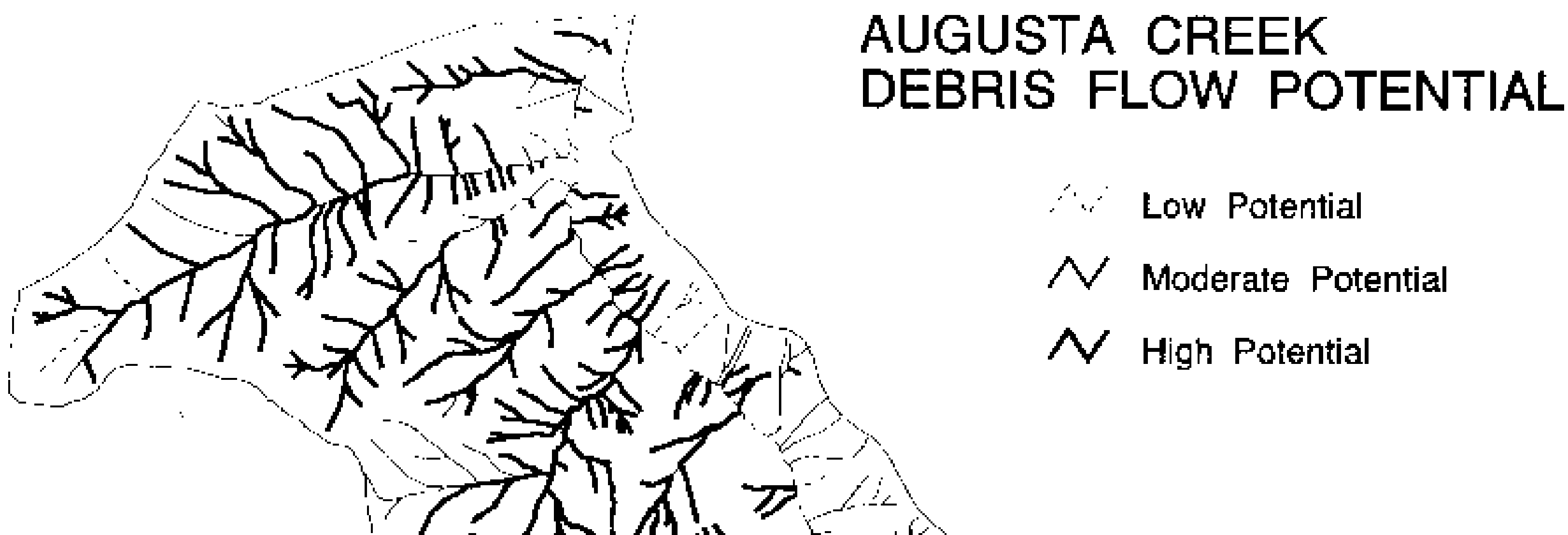


Figure V-I-8. Stream network for Augusta Creek watershed, Willamette National Forest, showing high-angle tributary junctions greater than 70 degrees.



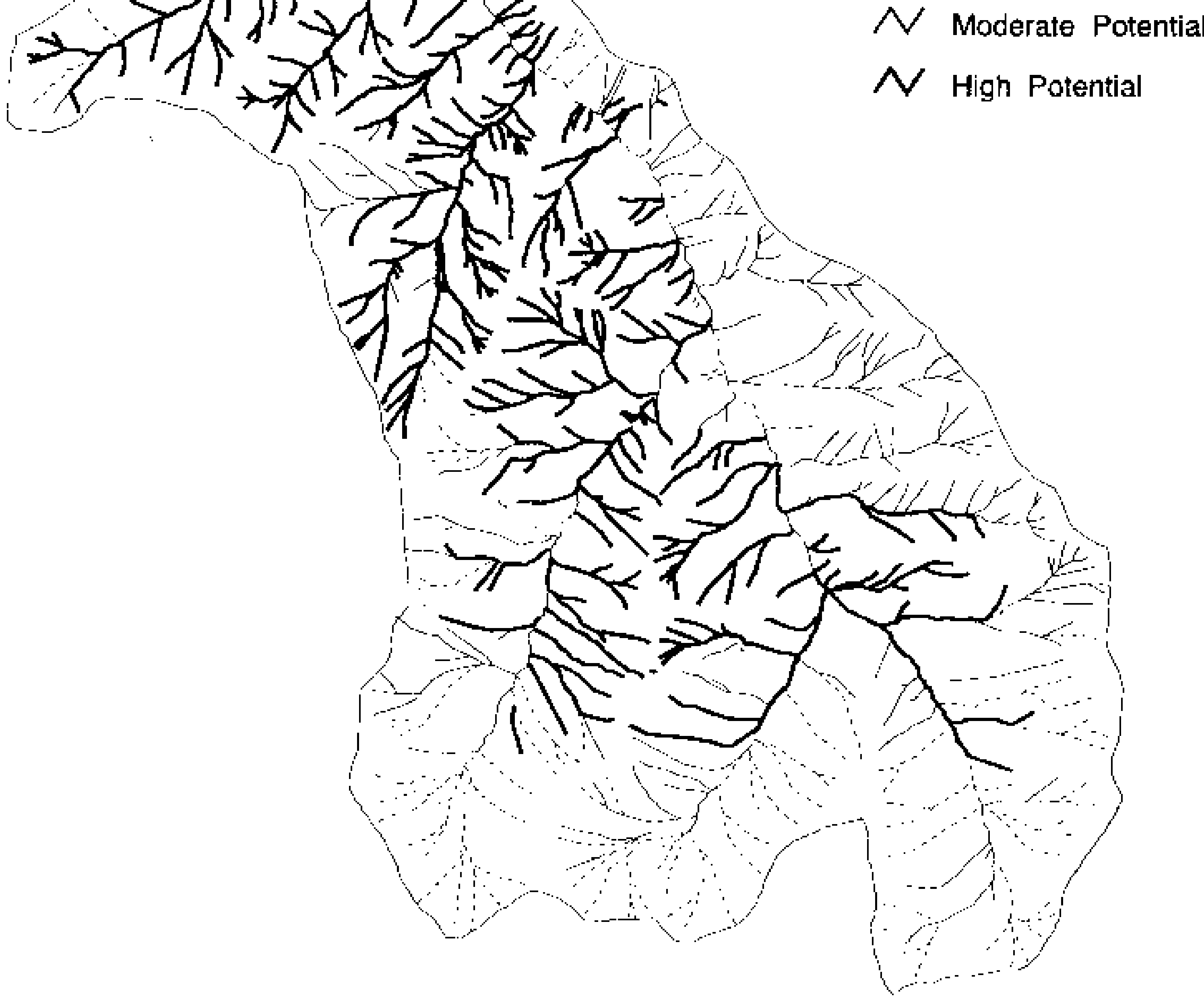
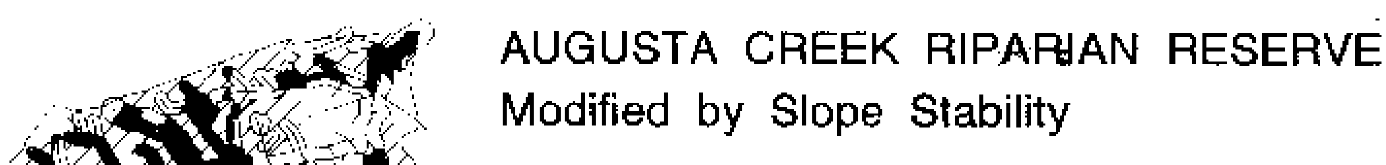


Figure V-1-9. Debris flow potential map for Augusta Creek basin, Willamette National Forest, based on slope stability and potential for debris flow runout from stream gradient and tributary junction analysis.



Creek basin, Willamette National Forest, based on slope stability and potential for debris flow runout from stream gradient and tributary junction analysis.

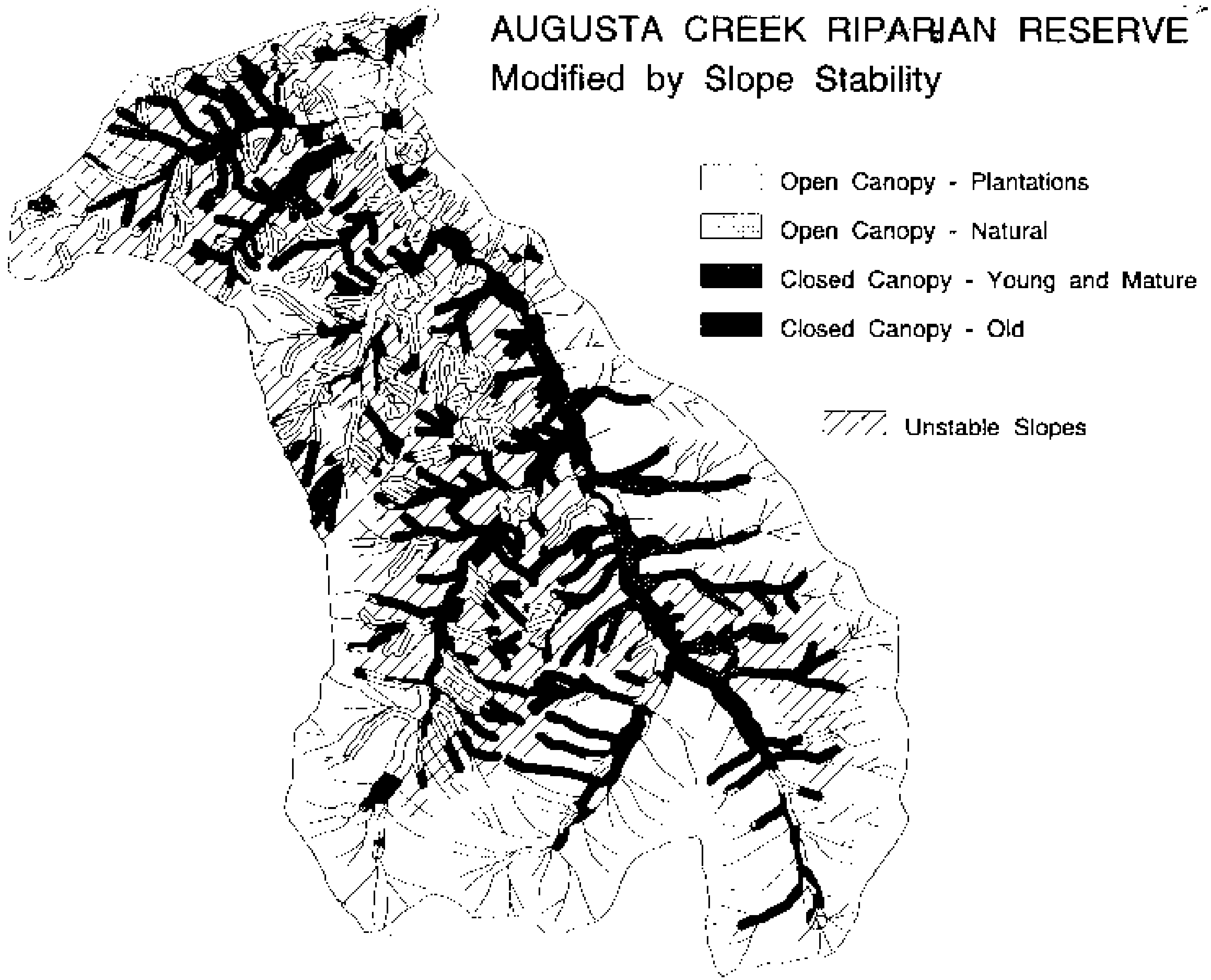


Figure V-I-10. Augusta Creek basin with Riparian Reserve 1 modified by slope stability considerations.

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Appendix J

Restoration of Watersheds and Riparian Ecosystems

Overview of Restoration

Forest management activities have altered the frequency, intensity, and s~ale of natural disturbance regimes. Hydrologic disturbance regimes that have been altered include streamflow and sedimentation, water temperature and chemistry, and stream channel/riparian area structural elements.

New land management strategies have been proposed that will attempt to mimic natural disturbance regimes. If successful, processes that degrade watersheds will be reversed. However a time lag will occur between implementing new ecosystem management strategies and the recovery of systems that were degraded under past management. Carefully applied ecosystem restoration treatments can accelerate natural recovery.

Restoration strategies should be comprehensive, addressing both watershed protection and restoration in an integrated program that moves ecosystems toward recovery and resilience.

We advocate an approach to watershed and riparian ecosystem restoration that emphasizes protecting the best habitats that remain (Pacific Rivers Council in press; Reeves and Sedell 1992), found in watersheds termed "refugia or Key Watersheds, particularly where these support species of special concern (Thomas 1993). Restoring watersheds that are currently degraded is also important in the long-term, to bring all public land ecosystems to full productivity and function.

A refugia (or key watershed) network serves as the anchor or cornerstone for further restoration design and strategy development. Refugia are habitats or environmental factors that convey spatial and temporal resistance and resilience to biotic communities degraded by biophysical disturbances. Landscape features associated with refugia may include localized microhabitats and zones within the channel, unique reaches, riparian vegetation, floodplaitis, and groundwater. These areas may serve as source areas for recolonization following natural or anthropogenic disturbances (Sedell et al. 1990).

A comprehensive approach to restoration that attempts to embrace the entire ecosystem is most appropriate. While such an approach is conceptually satisfying, in practice **it** is complex and frequently infeasible~ Only certain types of undesirable processes can be feasibly reversed. Some types of restoration that are desirable would require amounts of funding that cannot be reasonably anticipated. Practical restoration must start by determining all ecological restoration needs, then sifting these for the most important processes of concern, "treatability', cost-effectiveness, funding expectations, management situation, and institutional and socio-political considerations to arrive at the best implementable program.

The Role of Watershed Analysis

Watershed analysis is the first step in a watershed restoration program. It is used to determine restoration needs and strategies for watersheds of 20-200 square miles. Watershed analysis identifies physical and biological conditions and processes and where they occur on the landscape. This information is used to assess restoration needs and potentials and guide the detailed inventory of restoration sites.

To develop a comprehensive restoration strategy, **it** is crucial that all causes of degradation and their interactions be identified during of the watershed analysis. Landscape-level restoration planning should identify mechanisms to reestablish disturbance regimes and related physical, chemical, and biological characteristics that are within the range of natural variability.

We stress that the most successful method of habitat restoration has been watershed protection (Reeves et al. 1991). Any restoration programs and projects should be integrated with comprehensive strategies for watershed protection.

Types of Restoration Treatments

- **Hillslope restoration**

  Hillslope restoration consists of activities such as upgrading roads to control and prevent erosion (e.g., larger cuiverts, outsloping, rocking), decommissioning or obliteration of unneeded roads, controlling erosion on bare, eroding slopes, and improving derelict and degraded lands such as abandoned mines, gullied meadows, and areas where soils have become impoverished.

- **Riparian area restoration**

  Riparian restoration consists of activities such as planting and culturing native species of vegetation, thinning and interplanting existing stands of riparian vegetation, controlling streamside landsliding, restoration of riverine wetlands, control of grazing, correction of overdrained and gullied meadows, removal or upgrading of inappropriate recreational developments, and removal or upgrading of roads in riparian areas.

- **Stream channel restoration**

  Stream channel restoration consists of activities such as placing large woody material, rocks or artificial structures to catch or improve spawning gravel, improving migratory fish access, creating additional rearing habitat, and reconfiguring stream channels to improve habitat and stream channel dynamics.

Short-Term and Long-Term Restoration

Devising solutions to degraded conditions may involve both short-term and long-term solutions. Only a few problems have good short-term solutions. The nature of solutions depends on the nature of the particular problems in the watershed.

For example, insufficient large woody debris (LWD) in a stream channel has both a short-term solution -- placing/anchoring LWD in streams -- and a long-term solution -- establishing and managing riparian areas to provide sufficient amounts of LWD over the long-term.

Too much sediment has a short-term solution -- upsize culverts, harden crossings, decommission abandoned roads, or otherwise reduce sediment influx to streams -- and a
long-term solution -- minimize additional road construction, stringent requirements for future stream crossings, etc.

High stream temperatures has few short-term solutions (e.g., creating thermal refuges using coldwater diversions and pool excavation), and only one long-term solution; estaolish and manage riparian areas to provide sufficient shade.

If the problem is too little LWD and too much sediment, priority for restoration measures may be to reduce sediment inputs first and place in-stream structures second.

Monitoring

Long-term success of a restoration program depends not only on thorough planning but on post-project monitoring and evaluation. Many short-term treatments are straightforward and present little uncertainty as to their effectiveness. Most long-term solutions carry considerable uncertainties about how well they address long-term restoration objectives, and they must incorporate periodic site-specific and synoptic evaluations.

At a minimum, project monitoring should attempt to answer the following:

1. Are pre-project conditions identified and understood? Is the problem defined correctly?

2. Was the project implemented as planned?

3. Did the project accomplish the desired changes in habitat?

4. Did aquatic and riparian populations respond to the project?

Guidelines for Restoration Projects

Note: These guidelines are given to guide the overall choices of restoration strategies and tactics. Soni~e appropriate restoration projects cannot satisfy all of these,

1. All restoration programs should be preceded by a watershed analysis.

2. Projects should, whenever possible, provide a broad range of benefits to riparian and aquatic ecosystems.

3. Projects should address causes of degradation rather than symptoms.

4. Projects should have a well-defined life span. Expected restoration benefits should be realistically expressed in terms of the life span of the project.

5. Projects, once completed, should be self-sustaining, requiring minimum maintenance or operation.

6. Prolects should contribute to the restoration of historic composition and biodiversity of ecosystems, and bring disturbance regimes into the range of natural variability.

7. Projects should restore linkages between refugia and other isolated habitat units.

8. Projects should integrate watershed protection, including adjustment or cessation of management practices that are responsible for degraded habitat conditions.

Recommended major restoration activities

Many restoration opportunities exist. rhe most important opportunities fall into 3 categories: (1) control and prevention of road erosion and sedime~tati~n; (2) riparian silviculture, and; (3) stream channel improvements.

Control and prevention of road erosion and sedimentation

Federal lands within the range of the northern spotted owl contain approximately 110,000 miles of roads. A substantial proportion of this network, particularly roads built before 1980, constitutes a legacy of current and potential sources of damage to riparian and aquatic habitats, mostly through sedimentation. Without an active program of identifying and correcting problems, damage to aquatic habitats will continue for decades.

On public lands in the range of the northern spotted owl, road networks in upland areas are the most important source of accelerated delivery of sediment to anadromous fish habitats (Swanson et al. 1987). Road-related landsliding, surface erosion and stream channel diversions often deliver very large quantities of sediment to streams, both chronically and catastrophically during large storms. Many older roads with poor locations and inadequate drainage control and maintenance pose very high risks.

Roads modify natural hillslope drainage networks and accelerate erosion processes. These changes can alter physical processes in streams, leading to changes in streamflow regimes, sediment transport and storage, channel bank and bed configurations, substrate composition, and stability of slopes adjacent to streams. These changes can have significant biological consequences, that affect virtually all components of stream ecosystems (Furniss et al. 1991).

NOTE: Agency capacity to conduct road maintenance has recently declined greatly, as funds for mainter?ance and timber-purchaser-conducted maintenance have been drastically reduced. This is resulting in progressive degradation of road drainage structures and function causing erosion rates and potentials to increase. This will worsen unless additional funding for road maintenance is provided and/or road mileage is drastically reduced through decommissioning. If we do not maintain or remove the roads, mother nature will remove them, with serious consequences to aquatic habitats.

Applying erosion prevention and control treatments to high-risk roads can drastically reduce risks for future habitat damage. Many treatments have well-established effectiveness and are cost-effective. In watersheds that contain high quality habitat and have only limited road networks, large amounts of habitat can be secured with small expenditures to apply "storm-proofing and "decommissioning measures to roads (Harr and Nichols 1993).

Road treatments to protect and restore aquatic habitats fall into two broad categories:

1. Road decommissioning: includes closing and stabilizing of a road to eliminate potential for storm damage and preclude the need for maintenance, and;

2. Road upgrading: includes erosion control and prevention work on roads that will remain open.

Table V-J-1 gives the road functions that can damage riparian and aquatic habitats and some of the restoration solutions that can be applied.

Inventory of Roads to Determine Upgrading and Decommissioning Needs

Standards and Guidelines proposed in Appendix H require inventory of all roads and stream crossings, and improvement or obliteration of those that pose a substantial risk to riparian resources:

"Determine the influence of each road on the Aquatic Conservation Strategy Objectives through Watershed Analysis.

We estimate that a field inventory of all roads, not including other elements of watershed analysis, will require approximately 170 person-years to complete, at a cost of approximately $8 million. Methods for conducting these inventories are being prepared for inclusion in a Watershed Analysis Handbook.

Road decommissioning and upgrading are discussed in detail below

Decommissioning of Unnecessary, Unstable, or Poorly Located Roads

Unneeded roads and roads that are currently or potentially damaging to riparian and aquatic resources should be removed or restored to control ongoing erosion and eliminate the potential for catastrophic failure. Most of these problems are associated with older roads that were located in sensitive terrain and roads that have been essentially abandoned but are not adequately configured for long-term drainage. These roads are "loaded guns, waiting for the next large storm to fail and damage streams. Harr and Nichols (1993) found that, during the a major runoff event, roads that were "decommissioned by removing unstable fills and stream crossings suffered almost no erosion, while nearby roads that were scheduled for but had not yet received decommissioning were extensively eroded and caused severe stream damage.

Decommissioning means removing those elements of a road that reroute hillslope drainage and present slope stability hazards. Another term for this is for "hydrologic obliteration. This treatment may be applied to unneeded roads and to roads that present high hazards to habitat~ that cannot be eliminated through road upgrading. Road decommissioning includes:

- Removal of culverts.
- Decompaction of the road surface (ripping).
- Outsloping.
- Waterbarring.
- Removal of unstable or potentially unstable fills.

Table V-J-1. Road functions that can damage riparian and aquatic habitats and some of the restoration solutions that can be applied.

Type of problem Erosion Sedimentation	Location of problem	Decommissioning solution	Upgrading solution
Mass failure	fillslopes	•Pull unstable sidecast and place in stable location •Control drainage to prevent saturation of residual fills	•Replace unstable fills with stable configuration •Control drainage to prevent saturation of fills •Relocate road section to avoid oversteepened and unstable geomorphic features
	cutbanks	•Buttress cuts with pulled fill material •Obliterate inboard ditch to prevent undercutting of cutbank	•Outslope roads to eliminate cutslope undermining by ditch and ditch transport of cutslope-derived sediments
Surface erosion	fillslopes	•Pull steep fills and sidecast. •Protect surface with mulch and revegetate •Control drainage to prevent concentrated runoff	•Protect surface with mulch and revegetate •Outslope road to disperse runoff and limit surface-derived sediment transport
	cutbanks	•Mulch and revegetate if feasible	•Mulch and revegetate if feasible
	road surface	•Decompact, outslope, mulch and revegetate	•Rock surface, outslope road to disperse runoff and sediment, •Install rolling dips or other cross-drain structures
Fluvial erosion	ditch	•Remove ditch or cross drain very	

		•Control drainage to prevent concentrated runoff	limit surface-derived sediment transport
	cutbanks	•Mulch and revegetate if feasible	•Mulch and revegetate if feasible
	road surface	•Decompact, outslope, mulch and revegetate	•Rock surface, outslope road to disperse runoff and sediment, •Install rolling dips or other cross-drain structures
Fluvial erosion	ditch	•Remove ditch or cross drain very	
	ditch relief culvert outlets	•Remove culverts and establish frequent cross-drainage, or thoroughly disperse drainage	•Install more frequent relief culverts •Add energy dissipation or downspouts
Stream crossing failure	stream crossings and inboard ditches	•Remove stream crossings •Backslope fills to stable angle •Mulch and revegetate fills	•Upgrade stream crossing structure to accommodate the 100-year or greater stormflows •Install trash racks •Install debris handling structures (drop inlet, etc.) •Modify inlet configuration •Harden crossing to resist failure or contribute minimal damage upon failure
Diversion of streams at stream crossings	stream crossings	•Remove stream crossings •Backslope fills to stable angle •Mulch and revegetate fills	•Install crossdrain (waterbar, rolling dip) just downgrade from crossing; •Install "failure dip" on crossing fill
Peak flow augmentation	general	•Remove inboard ditch •Decompact road •Outslope road •Place excavated fills against cutbanks to approximate normal hillslope drainage	•Outslope road to avoid rapid routing of surface runoff, intercepted interflow •Employ frequent ditch relief cross-drains to prevent large accumulations of discharge
Fish Migration Blockage	stream crossings	•Remove stream crossings	•Replace impassable structures •Modify culvert to provide conditions for passage
Stream Channel		•Pull road fills back, remove from	•Relocate road to remove encroaching
Human access leading to:			
poaching		•Remove road	•Control access during critical periods
inappropriate recreational uses		•Remove access through road decommissioning	•Restrict access (gating during critical periods, fencing, etc.) •Education •Enforcement
spill hazards	stream crossings and ditches	•Remove access through road decommissioning	•Enforcement •Remove inboard ditch (outslope) •Adequate spill contingency planning and response

Decommissioning differs from full site restoration that attempts to recontour slopes with nearly complete removal of road (Spreiter 1991). With decommissioning, most of the roadbed is left in place, facilitating inexpensive reconstruction should the need arise (fire, management emphasis change, etc.), but hydrologic risks are greatly reduced.

In some cases, full site restoration may be appropriate, such as in highly visual sensitivity areas, or as part of a complete ecosystem restoration treatment,~ We expect, however, that decommissioning will be more appropriate and cost-eff~ctivè in most cases where the protection of aquatic habitats is the primary objective.

We believe the decommissioning of unneeded, neglected, and high-impact roads to be the most urgent and significant restoration need on public lands in the range of the Northern spotted owl, based on the magnitude of ongoing and potential effects to aquatic ecosystems.

Upgrading or "Storm-Proofing Roads that will Continue to be Needed for Land Management

Road upgrading is done on roads that will remain open to control the ongoing erosion and sedimentation, reduce the risk of future erosion and sedimentation, and correct road-related barriers to fish migration.

Preventing chronic erosion and reducing the risks of catastrophic storm-related erosion is feasible and cost-effective for many roads. "Storm-proofing roads to reduce or eliminate the risk of severe road-related erosion during large storms is particularly important because catastrophic road-related erosion from large storms has been the most significant source of management-related aquatic habitat damage observed in many watersheds.

Control of chronic erosion and sedimentation

Many techniques are available for reducing chronic erosion and sedimentation from roads. Techniques must be tailored to the specific erosional processes that are active. Types of techniques include:

· Conversion of inslope/ditch roads to outslope roads (usually with backup surface drainage control such as rolling dips).

· Relieving inboard ditchlines more frequently to prevent critical amounts of drainage water discharge.

· Rocking road surfaces to armor against road surface erosion and maintain design drainage configuration against traffic impacts, especially where roads must remain open during wet periods.

· Mulching and revegetating bare, erosion-prone surfaces such as cuts and fills, wherever derived sediments have access to the stream system.

· Site-specific drainage solutions applied wherever erosive concentrations of road drainage or streamflow are causing sediment delivery to streams.

· Adopting maintenance techniques that are specifically designed and conducted to control erosion and sedimentation.
Reducing risks of catastrophic damage resulting from large storms

Certain types of road features can lead to high risks of catastrophic erosion and sedimentation, such as undersized stream crossing structures, stream crossings with stream diversion potential, unstable fills, and road drainage routing that can trigger landslides. Types of remedial techniques include:

· Correcting stream diversion potential at stream crossings, sucl~ th~ if a crossing fails or overtops, streamflow is not diverted down the road or ditchline.

· Upgrading stream crossings to pass at least the 100-year streamflow, plus associated bedload and debris; using a varietY of techniques such as larger culverts, trash racks, drop inlets, inlet configuration changes, hardening crossing fills, and controlling sediment and debris loading upstream of the crossing.

· Removing and reconfiguring unstable fills.

· Relocating road sections that pose high risks of landsliding during large storms.

· Converting inslope/ditch roads to outslope roads.

· Rerouting of road drainage to stable receiving areas.

Estimated Magnitude of Road Decommissioning and Upgrading

Prior to site-specific inventory of roads, the magnitude of opportunities is unknown. Little inventory has been conducted to determine current road restoration needs. Decisions on what restoration or upgrading treatments might be applied depends on many factors, including the severity of ongoing or potential effects, transportation needs, the value and sensitivity of downstream uses, social expectations, the "treatability of the problems, the costs of treatment, and a variety of other factors. Thus, the magnitude of the need for road decommissioning and upgrading is unknown at this time.

However, we can make some estimates of the miles of road that might be involved if we make some assufnptions. We stress that these are rough estimates for short-term planning purposes only, and that the actual magnitude of opportunities will require intensive inventories, is likely to differ from these estimates.

Total road mileage:

Total inventoried road miles (5/93) on public lands in the range of the northern spotted owl 87554

Estimated actual road miles on public lands in the range of the northern spotted owl..109,400b
Total miles of FS Level 1 (closed but not decommissioned) 11,530
Total miles of FS Level 2 (high-clearance vehicles only) 43,030
Total miles of ES Level I and Level 2,500
BLM miles in equivalent Levels 1 & 2 estimated at 15,503
Total miles, ES and BLM equivalent Levels 1 & 2...70,000

b-Estimated actual mileage. Substantial mileage of roads are not included in current transportation databases, as they are not considered to be part of the transportation "system," but they exist. Based on discussions with Forest Engineers, we estimate that the magnitude of uninventoried road miles is about 25% of the inventoried road miles.

Approximately 20% of total road mileage is in roads that are maintained for full public use; that is, maintenance level 3,4 & 5, which are constructed and maintained such that a sedan can travel safely.

Three approaches to estimation of the amount of road to be treated are given.

Approach 1. Assume that 20 percent of high-clearance vehicle and closed roads (in Maintenance Levels 1 and 2 and BLM equivalents) are unneeded, are causing significant damage to aquatic habitat, and are to be decommissioned. Further assume that of the 80 percent of the road network in maintenance Levels 1 and 2 that is not decommissioned 50 percent needs upgrading:

Mileage to treat
Miles to be decommissioned 14,000
Miles to be upgraded 28,000

Approach 2. Assume only roads in key watersheds are to be treated. Assume that one-third of the roads in key watersheds need to be decommissioned one- third need to be upgraded, and one-third do not need any treatment.

Miles to treat
Approximate mileage of roads in key watersheds 23,000 (inventoried)
29,000 (est. actual)
Miles to be decommissioned 9,600
Miles to be upgraded 9,600

Approach 3. Avoid catastrophic damage by treating only the roads that present the greatest risks. Assume that five percent of roads fall into this category, and that half of these will be decommissioned and half upgraded.

Mileage to treat
Mileage to be decommissioned 2,700
Mileage to be upgrade 2,700

Riparian Silviculture: Planting, Thinning, and other Vegetation Management in Riparian Areas

Large areas of riparian land can benefit from establishing and managing of vegetation. Planting trees and brush on eroding strean~side landslides improves riparian and aquatic habitats (Furniss 1989). Beschta et al. (1991) determined that the restoration of vegetation adapted to riparian environments and the natural succession of riparian plant communities is necessary to recreate sustainable salmonid habitat and should be the focal point for fish habitat improvement programs.

Multiple benefits to ecosystems accrue from riparian revegetation, including:

(1) Topsoil enriched and increased long-term ecosystem productivity; (2) control and prevention of erosion; (3) improved biological diversity: (4) enhanced ecosystem resilience to disturbance; (5) accelerated plant succession on recently disturbed areas, leading to more favorable plant cover and more "mature ecosystems; (6) improved wildlife habitat; (7) Improved aesthetics; and, (8) employment.
Types of riparian silviculture projects include:

·Planting on streamside landslides.

·Planting on flood deposit "high-bars near streams and rivers.

·Planting on disturbed areas such as skid trails, landings, hot-burned streamside areas, degraded meadows, and cable corridors.

·Interplanting conifers such as Douglas-fir and ponderosa pine among even-aged riparian hardwoods (such as alder and willow).

·Thinning to promote growth and vigor of riparian trees.

· Aerial seeding of inaccessible areas, such as landslide surfaces and riparian areas.

Estimated Magnitude of Riparian Silviculture

Comprehensive inventories of opportunities for riparian silviculture have not been conducted on most Forests and BLM Districts. However, we can make rough order-of- magnitude estimates of the land areas that might benefit from riparian silviculture treatments for short-term planning purposes. Intensive inventories are needed to accurately define the nature, magnitude and locations of areas where riparian silviculture can produce cost-effective benefits.

Total length of stream on public lands in the range of the northern spotted owl. Assuming streamside landslides, eroding areas, plantable/thinnable riparian vegetation
and other riparian restoration opportunities occupy 10 percent of stream length and are 100 feet wide:
Area of riparian lands to treat ....264,856 acres
Assume that only 400/0 of these are "treatable (plantable, accessible, operable):
Total treatable area ....105,942 acres

Stream Channel Improvements

In the past 10 years, large programs of in-stream fish habitat modification have been undertaken on both National Forest and Bureau of

Land Management lands. Many projects proceeded with inadeq~uate planning and post-project evaluation. Consequently, in-stream habi;at modification programs have recently been criticized as ineffective (Beschta et al. 1991; Frissell and Nawa 1992).

In-stream restoration activities that are based on accurately interpreting watershed, stream, and biological processes and deficiencies can be an important component of an overall program of restoring fish habitats. In-stream restoration measures are inherently short-term and must be accompanied by watershed-wide restoration and protection to achieve long-term restoration. It is important to note that short-term solutions, while not complete, may be crucial as part of a program to recover anadromous fish stocks, while long-term restoration measures have time to become effective.

There are numerous examples of how such activities have improved fish habitats (House et al. 1991, Crispin et al. in press). Special emphasis should be afforded to careful planning, monitoring and evaluation of all in-stream habitat modification projects (Reeves et al., 1991).

Magnitude of in-stream habitat modification potential may be broadly estimated as follows:
Miles of fish-bearing streams within the range of the northern spotted owl - - 24,439
Estimated proportion of fish-Lsring stream miles that have h.sh:tat modification opportunities 5%
Estimated miles of stream having hshit it moditio scion oppot-tunhties 1,250

Coordinated Action with Private Landowners

In recent years including private landowners in watershed restoration programs has met with considerable success in many areas. For many watersheds, participation of private landowners is essential to achieving restoration goals. Both the Forest Service and the Bureau of Land Management have actively encouraged field personnel to establish partnerships and cooperative projects.

Models for collaborative planning and project implementation have demonstrated methods to bring various agencies, institutions, owners, and citizens into comprehensive restoration programs that have far more potential for successful outcomes than single- party programs.

Such collaborative efforts usually require an agency to initiate the idea and promote its development. Federal land-management agencies are ideally suited for this role but must invest funds and time, and take risks that for some initiatives collaboration might not be successful.

Grants for restoration work, such as provided by Section 3 19(h) of the Clean Waters Act, can provide incentive to landowners to participate. Agencies can facilitate the securing of such grants, which can help to facilitate broader cooperation.

Involvement of owners, users, regulators, and managers in restoration holds excellent prospects for long-term success of both restoration and protection goals. We recommend continued emphasis and encouragement of this approach in mixed- ownership watersheds.

Elements of a 10-year Forest Ecosystem Restoration Program

1. Establish a program for providing adapted native revegetation stock for restoration work (years 1- 10).

Securing reliable supplies of natis'v, adapted revegetation plant materials for restoration work requires 2-3 years and involves identification of suitable species, seed collection, and growing. Waiting for full identification of restoration work is usually infeasible because of the time needed for seed collection and grow-out of the plants. Species, seed zones, and numbers of plants will be necessarily somewhat speculative. The alternative is either to not have suitable plant materials or to defer restoration treatments for 2 years or more after they are fully designed. This step should commence immediately.

2. **Assemble a regional interagency restoration advisory team** (year 1) **to:**

·Develop watershed analysis methods for restoration.

· Conduct initial prioritization of watersheds for pre-restoration watershed analysis.

· Develop ecological restoration priorities.

· Developed regional technical criteria for evaluating restoration treatments.

· Provide resources to assist restorationists (expertise, analysis tools, information exchange).

· Keep emergency restoration contingency plans current.

· Facilitate rapid team assembly to plan for disasters, such as fire and flood.

3. **Reconnaissance assessment for all lands** (year 1)

Conduct a reconnaissance-level assessment of all public lands in the northern spotted owl range using aerial photos, local knowledge and cursory field survey to identify major problem areas and high-priorits~ watersheds for detailed assessments and watershed anal vs is.

4. Establish Criteria to prioritize watersheds for watershed analysis (year 1) **and specific work sites and develop scheduling of restoration work** (years 1 **& 2), based on:**

· The immediacy of biological and physical restoration at the 20-200 square mile watershed scale.

· The "treatahilitv' of the kinds of watershed problems that occur. Use risk-cost analysis to broadly estimate the efficacy of treatment for the categories of problems and restoration solutions.

· Biological resources, especiallY listed species and species considered to be "at-risk .

· Refugia for anadromous fish and their specific restoration needs.

· The degiee to which :estoration treatments could contribute to long-term productivity, diversity jncl resilience of riparian and aquatic ecosystems.

5. Prioritize watersheds for watershed analysis based on these criteria (year 1)

The Interagency Team should establish the priority watersheds for restoration. Initial priorities should focus on I'ier 1 Rev ~~ atersheds, and on other areas that may exhibit characteristics of refugia as described by Sedell et al. (1990). That is, watersheds that have good to very good fish habitat, cc where good h.cbitats can he readily restored.

6. Conduct watershed analysis on selected watersheds (years 1 and 2)

We estimate the cost for watershed analysis to vary between SO.25./acre to $1.50/acre, depending on the size of the watershed and the quality of the existing information base.

7. Conduct public scoping on potential restoration work (year 2).

8. Conduct watershed analysis for restoration, including restoration objectives and detailed work activity descriptions (years 2 & 3).

Watershed analysis will identify watershed disturbance processes and where they occur on the landscape; current conditions of hillslopes and channels; status of aquatic
communities, limiting factors for riparian ecosystems, inventory of past land use **- -** practices, and where opportunities exist for effective restoration. ~

Watershed analysis will identify objectives for restoration activities. The objectives establish the framework for restoration work, including cost-effectiveness (or cost-risk) thresholds for deciding which treatments are worthwhile, what measures are needed, where they are to be carried out, which techniques need to be used, what sequence of actions should be planned, and how the work is to be accomplished.

9. Prepare NEPA documents (years 2&3)

10. Implement restoration work (years 2-10)

11. Monitor, evaluate and document work (year 4-10)

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Appendix K

Current State Forest Practice Regulations for Riparian Protection

California

The width of the Watercourse and Lake Protection Zone is determined by slope steepness and water class. Rules are provided for all activities within the Watercourse and Lake Protection Zone. Timber harvest is allowed with appropriate equipment. Up to 50 percent of the overstory and 50 percent of the understory may be removed in the protection zone. Of the 50 percent overstory, at least 25 percent must be coniferous, but exceptions can be made. Exceptions for higher levels of removal are given. Existing roads in all buffers can be utilized, but in general no new roads are allowed in Class I or II zones. Specifications appear in the rules for roadbuilding, use of heavy equipment, prescribed burning, and other common silvicultural practices.

Water class characteristics or key indicator beneficial use for Watercourse and Lake Protection Zone:

Class I-1) Domestic water supplies, including springs on site and/or within 100 feet downstream of the operations area and/or

2) Fish always present or seasonally present onsite includes habitat to sustain fish migration and spawning.

Class II-1) Fish always or seasonally present downstream and/or

2) Aquatic habitat for non-fish species

Class III- No aquatic life present, watercourse showing evidence being capable of sediment transport. Class I and II waters under normal high water flow conditions after completion of timber operations.

Class IV- Man made water courses, usually downstream, established domestic, agricultural, hydro-electric supply or other beneficial uses.

Stream and riparian protection; California Forest Practice Rules

Stream Class	Watercourse and Lake Protection Zone widths		
Class I	Slope Class	< 30	75 feet
	Slope Class	30-50	100 feet
	Slope Class	> 50	150 feet
Class II	Slope Class	< 30	50 feet
	Slope Class	30-50	75 feet
	Slope Class	> 50	100 feet
Class III & IV	No minimum protection		

Washington

Under the Washington State Forest Practices Rules and Regulations Washington has designated five water categories determined by water usage and water quality. Riparian Management Zones are measured horizontally from the ordinary high water mark of Type 1, 2, and 3 waters and must extend to the line where vegetation changes from wetland to upland plant community or to a line required to leave sufficient shade. The widths of the riparian management zones currently being implemented in Washington are designed to, on the average, recruit 70 percent of historic large woody debris.

Watershed analysis is required on certain sensitive watersheds.

Stream and riparian protection, Washington State Forest Practices Rules and Regulations

Stream type	Riparian management area
Fish bearing streams	25-100 ft
Non-fish bearing perennial streams	No minimum protection
Intermittent/ephemeral streams	No minimum protection

Watershed analysis is a Best Management Practice designed to assess selected biological and physical parameters of the environment within a watershed administration unit. The watershed analysis also provides information needed to regulate cumulative impacts of forest practices on fish, water, and capital improvements on state land and its subdivisions. Level I assessments are low intensity evaluations of a watershed administration unit to identify areas of resource sensitivity and to determine whether a more sensitive level 2 Assessment is needed.

Oregon

Requirements are set for the average width of Riparian Management Areas for streams, estuaries, lakes and wetlands. The measurement is the average width over the length of stream where the operation occurs. The absolute width may vary depending on topography, vegetative cover, needs of the harvesting plan, and aquatic and wildlife habitat needs. Riparian Management Areas must he managed for protection of riparian values along Class I streams. The Riparian Management Area width on each side of the stream shall average 3 times the stream width, but shall not he less than 25 feet or greater than 100 feet. In Riparian Management Areas adjacent to Class I waters, an average of 75 perceni' o~ the pre-operational shade must be maintained over the aquatic area; at least 50 percent of the pre-operational tree canopy must be maintained; and conifers must be retained in the half of the Riparian Management Area closest to the water (or an average of 25 feet of the water whichever is greater).

Class I Waters - fishery and domestic use
Class II SP Waters - Class II waters that have a special impact on Class I waters.
Class II Waters are not Class I but have a defined channel or bed

Stream and riparian protection,; Oregon Forest Practices Purpose Act

Stream type	Riparian Management Area
Class I	25-100 feet depending on width of stream
Class II SP	25-100 feet with exceptions; shade protection only
Class II waters	No minimum projections